CIVIL ENGINEERING

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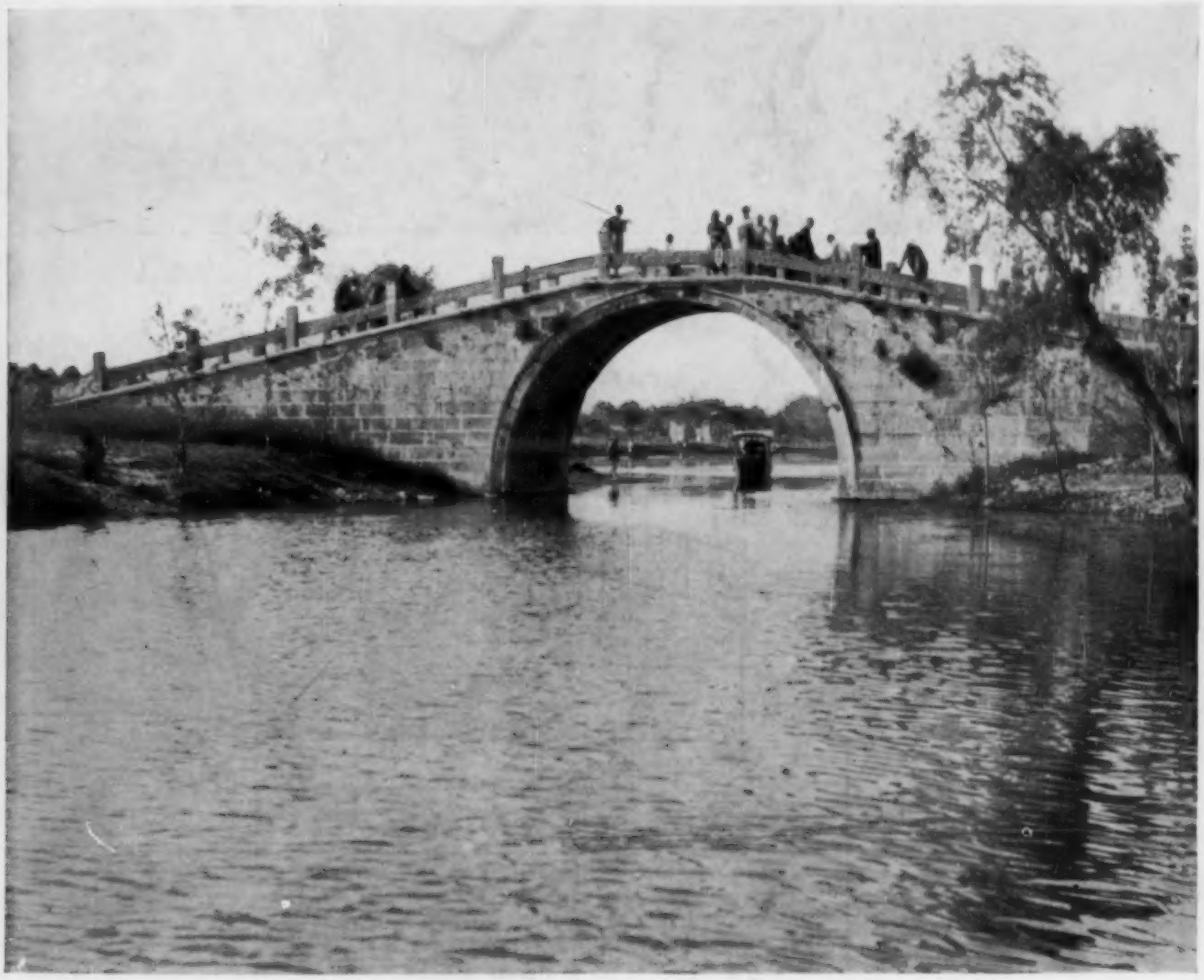
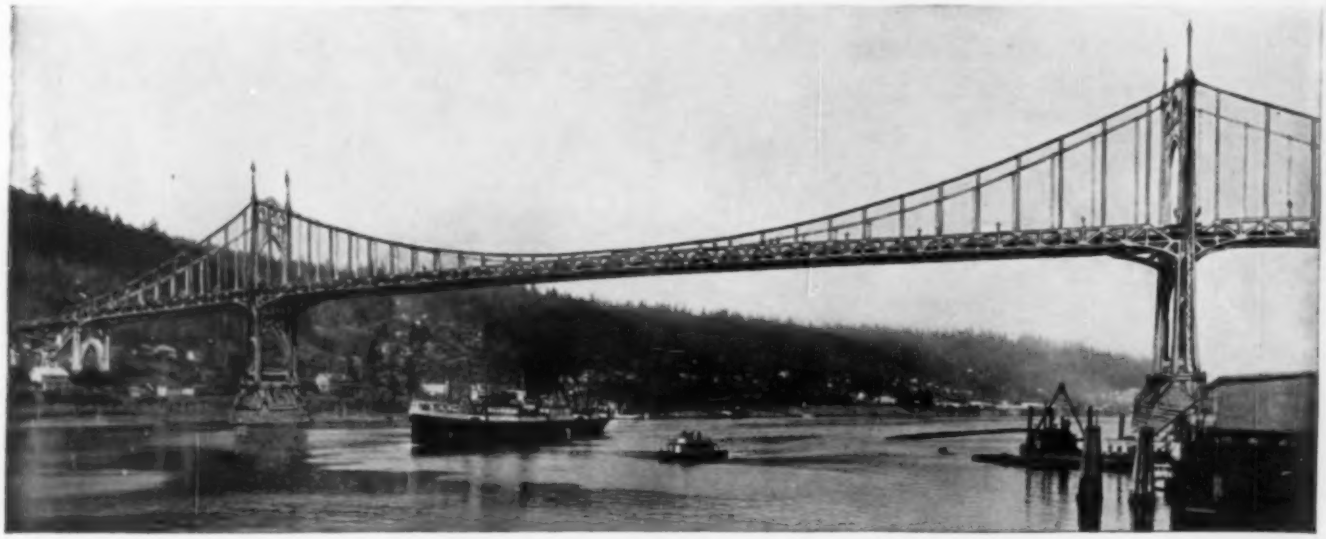


TYPICAL CHINESE MASONRY ARCH BRIDGE

Volume 1 — AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852 — Number 5

FEBRUARY 1931

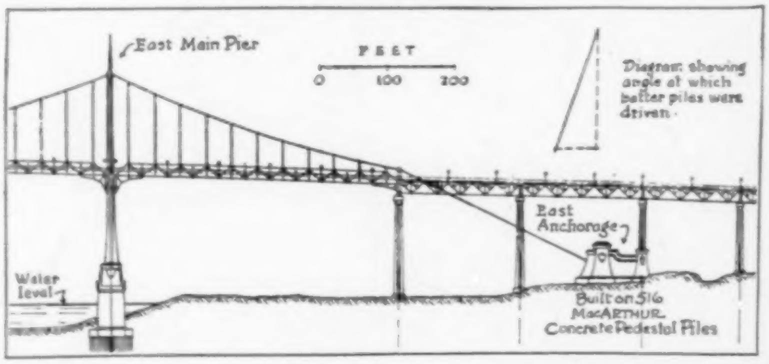
East Anchorage of great Portland, Oregon Bridge is built upon MacARTHUR Pedestal Piles



The engineers' drawing of the main portion of St. Johns Bridge, Portland, Oregon, is shown superimposed on a photograph of the bridge site on the Willamette River (looking north.)

ROBINSON & STEINMAN, CONSULTING ENGINEERS
New York and Portland
The Gilpin Construction Co., General Contractors, Portland

This bridge will have a span of 1,207 feet, the longest west of Detroit; and a clear height of 205 feet, making it the highest bridge over a navigable river.



This elevation shows the *east main pier*, the *east cable bent pier* and the *east anchorage*. The piles upon which this anchorage stands average 29 feet in length. Half of these piles were driven vertically and half at a 1 to 3 batter as shown, upper right corner of drawing.

Sub-soil conditions at the location of the east anchorage called for the use of our pedestal type pile (we drive every type.) Concrete Piles were necessary because they would not be below the permanent water level. Using pedestal type piles effected a saving in the number of piles and the depth to which the piles had to be driven.

A letter to us from the Gilpin Construction Co., dated July 9, 1930, states: "We wish to express our appreciation and satisfaction of the manner in which your company carried out your contract with us for the concrete piling on the St. Johns Bridge job. Mr. Sneed, who had charge of this work for you, handled the work in a businesslike and creditable manner."

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Among Our Writers

F. E. Weymouth, during 22 years connection with the U.S. Reclamation Service, had contact with investigations and construction of all reclamation work in the West, including the Arrowrock Dam. Later he was President of Brock and Weymouth, Engineers, and then had three years service in Mexico in charge of construction of irrigation and power projects for J. G. White Corporation.

Morris Knowles has been closely identified with the development of Pittsburgh, his accomplishments including the design and construction of a filtration system and new water supply for the city. He is the author of *Industrial Housing*, and has been a Director of the Society.

Charles D. Purdon began his engineering work over 60 years ago, when he became associated with the Intercolonial Railway. Since that time he has served several railroads in various capacities, being at present Consulting Engineer for the St. Louis-Southwestern Railway.

Calvin V. Davis is a graduate of Drexel Institute. Since 1923, he has been with the Ambursen Construction Company, designing dams, hydroelectric plants, and miscellaneous hydraulic structures.

Harold E. Magnuson was, immediately after graduating from Brown University, engineer with the Providence, R.I., Water Supply Board. His subsequent years of work with the Associated Factory Mutual Fire Insurance Company qualify him to speak with authority on fire protection. He is now a member of the firm of Thorndike and Magnuson, advertisings.

Emory W. Lane, Research Engineer with the U.S. Bureau of Reclamation, writes on China from the point of view of several years of close contact with the engineering development of the country.

John F. Coleman, Past-President of the American Society of Civil Engineers, has been identified with many of the engineering projects of the South. He is, in particular, an authority on the land reclamation, drainage and flood control problems of the Mississippi Valley.

Eldred D. Smith, a recent graduate of Drexel Institute, was Inspector during construction of the Brook's Hollow Dam. His paper on this project won a prize in the 1930 Student Chapter contest offered by the Philadelphia Section.

Clyde M. Cram, although chiefly identified with the work of municipal improvement in Los Angeles and Long Beach, Calif., is also distinguished for his connection with the construction of the Columbia River North and South Jetties.

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February 1931

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Volume 1 February 1931 Number 5

Colorado River Aqueduct

Route Selected for Metropolitan Water District Requires Pumping

By F. E. Weymouth
Member American Society of Civil Engineers
Chief Engineer, Metropolitan Water District of Southern California, Los Angeles

Southern California, without water, would return to the desert condition from which it has emerged. Its growth has been so great that it is now depleting all of its present available supplies of water. Eighteen years ago Los Angeles completed the Owens River Aqueduct, bringing water from the eastern slopes of the Sierra Nevadas, 250 miles away. That city, within recent months, has voted a $38,800,000 bond issue for extending and enlarging its Owens River Aqueduct to tap the waters of the Mono Basin about 60 miles northwest, and is now engaged in its construction.

The Colorado River being the only available source for additional water, Mr. Weymouth here describes the selection of the most advantageous of the 60 routes examined, and compares six which were intensively studied. Already more than a million dollars have been expended upon investigations and surveys of the desert regions through which the two-hundred-million-dollar aqueduct is to pass; and it has been characterized as the greatest engineering undertaking in America today.

The material from which this paper was prepared was originally presented by Mr. Weymouth before a joint meeting of the Los Angeles sections of the four Founder Societies and first published in the December 1930 issue of "ASCE," the technical publication of the Los Angeles Section of the Society.

The Metropolitan Water District of Southern California is, in effect, a confederation of cities in the south coastal plain. It was organized in 1928 under the Metropolitan Water District Act of 1927, which authorizes the joining together of non-contiguous municipalities, or water districts, for the purpose of developing a domestic water supply. The district is governed by a Board of Directors composed of at least one director from each city, the voting power being distributed among the member cities on the basis of one vote for each $10,000,000 of assessed valuation, with the provision that no city shall have more than 50 per cent of the voting strength of the board. Each city has the right to appoint an additional director for each $200,000,000 of assessed valuation without, however, increasing its voting power. The enabling act requires that the water be distributed among the member cities in proportion to their assessed valuations, the apportionment to be adjusted from time to time to conform to the growth of the various communities.

There are, at the present time, 11 cities in the district, having an aggregate population of 1,850,000, and an assessed valuation of two and one-third billion dollars. The act provides for the addition of other cities from time to time, and for separations. Three new applications have been recently submitted and formally accepted by the Board of Directors. Ratification by the people of the applicant cities is necessary before these applications become effective. Several other communities have expressed interest in the project. The area, which may be regarded as prospectively a part of the Metropolitan Water District, has a present population of 2,750,000 and this number must be considered in estimating future demands on the water supply.

Upper Parker Dam Site Looking Upstream
For a Mile the Colorado Here Flows in a Rock-Bound Channel

Present Demand for Water

In 1929–1930 the City of Los Angeles used a total of 268,000 acre-ft. of water. A portion of this was developed from local wells; some of it was derived from surface flows in Owens Valley; and some was pumped from the Owens Valley gravels. No appreciable flows, subject to diversion by the city, went to waste and no water was accumulated

in either surface or underground basins. In fact, ground water levels generally went down. In other words, the City of Los Angeles actually took more water from its sources of supply than was put back by nature. This does not mean that the city is actually facing an immediate water famine. There is still water in the underground basins available for emergency use, but the volume of underground water is not inexhaustible, and overdraft upon it cannot continue indefinitely. We are now, admittedly, in the midst of a dry cycle and some relief may ultimately be expected through increased rainfall.

Rainfall records at Los Angeles, for a 50-year period, are shown in Fig. 1. The precipitation has been declining, more or less gradually, since 1916. However, there have been many years with a lower rainfall than 1930, even in the brief period covered by these records. The 1893–1904 drought was more severe than the present one. It would be bold to assume that others, still more severe, will not occur in the future. It appears that Los Angeles is in a dangerous position as to future water supply, and it is evident that more water will be urgently needed by the time Colorado River water can be brought in.

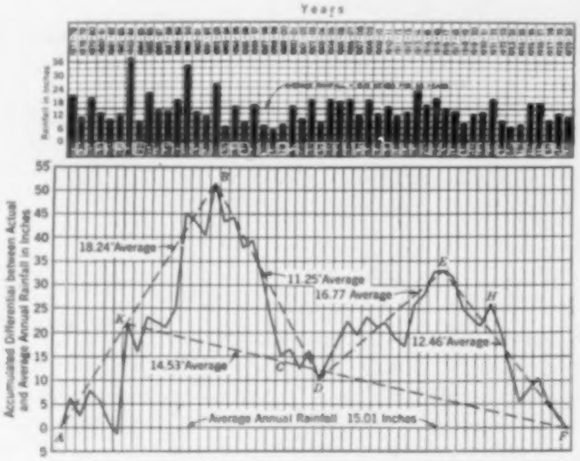


FIG. 1. ANNUAL RAINFALL RECORD, LOS ANGELES
With Accumulated Departures from the Mean

ESTIMATED ULTIMATE DEMAND

The habitable area of the coastal plain is approximately 2,200 square miles, or 1,400,000 acres. The contemplated Colorado River Aqueduct, after allowing for losses, will deliver something less than 1,000,000 acre-ft. per year into local storage reservoirs or, say, 0.70 acre-ft. per acre. The Los Angeles Aqueduct, extended to Mono Basin, can be depended upon for perhaps 0.20 of an acre-ft., bringing the supply up to 0.90. Run-off from the 3,900 square miles of the south coastal plain may be counted upon to supply an additional 0.4 acre-ft. per acre.

Then the total supply, with all prospective importations, amounts to approximately 1.30 acre-ft. per acre. This is a gross figure, and with no allowance for losses in handling and distributing. As an irrigation supply, it is a modest amount, but as a domestic supply it is low, even for sparsely settled sections, and it makes no allowance for the heavy usage in congested and industrial districts. This allowance will probably be slightly increased by sewage reclamation and perhaps more notably by "return flow" from irrigation when a more bountiful primary supply is made available.

A proposed aqueduct capacity of 1,500 sec-ft., or 1,086,000 acre-ft. per year at the point of diversion, was not selected by the above process of reasoning. But these general statements show that, although the region will not be overwhelmed by a surplus of water from the Colorado River Aqueduct, it will nevertheless be placed in a reasonably secure position for a time.

The amount of the proposed Colorado River diversion was arrived at by a study of predicted population curves, based upon past and present population trends and comparisons with the growth curves of other large and progressive communities, such as Chicago and New York.

From 1930 to 1980, the contemplated construction and amortization period, the estimated population increase for "Metropolitan Los Angeles" is 7,500,000. At the point of wholesale delivery, 1 sec-ft. of flow is sufficient for approximately 5,000 people. Therefore, according to these curves, the district will need the entire 1,500 sec-ft. of new water by 1980.

PRELIMINARY SURVEYS COMPLETED

That the Colorado River is the only adequate source of water near at hand, which can be delivered at a reasonable price, is universally conceded. Having decided to go to the Colorado to bring the water into the district, a problem of magnitude is presented, in the solution of which a vast amount of preliminary work has been done. When preliminary work was first started in 1923, the area between San Bernardino and the river was largely unsurveyed and the configuration was not such as to point to any single best line. Accordingly, a general topographic survey was begun, and maps were assembled from which the problem could be studied with facility. As an aid in engineering studies and to assist the public in comprehending the magnitude of the problem, an accurate relief map of the area was prepared. This map is 25 ft. long by 25 ft. in maximum width.

When maps became available, a large number of office locations and preliminary estimates were made. These led to the selection of certain prospective routes for an aqueduct. These routes were run out in the field and studied in detail on the ground by the engineering forces of the district and by a corps of competent geologists, with the result that the problem was narrowed down to one line from each of the several possible diversion points on the river. The locations of these six lines are shown in Fig. 2.

INTENSIVE GEOLOGICAL STUDIES MADE

The San Bernardino and San Jacinto mountains stand as a great barrier between the coastal plain and the desert country lying east of them. The region which the aqueduct must traverse is generally rough and rugged. Mountain masses rise above the general level of the intervening valleys, which are deeply filled with detrital material. These valleys often form enclosed basins which are water bearing. The main fault systems

are located along, and to the west of, the San Bernardino and San Jacinto mountains. These systems are generally parallel and extend toward the southeast into Mexico. The most important of these fault lines is that known as the San Andreas, which traverses fully one-half the length of the state. Dr. John P. Buwalda, of the California Institute of Technology, characterizes this as the "most important fault in California, perhaps on the entire earth."

Recent movements of magnitude have occurred at several points along this fault, which any aqueduct from the Colorado River to the Metropolitan Water District must cross. It is considered important that the crossing be made on the surface, and approximately at right angles.

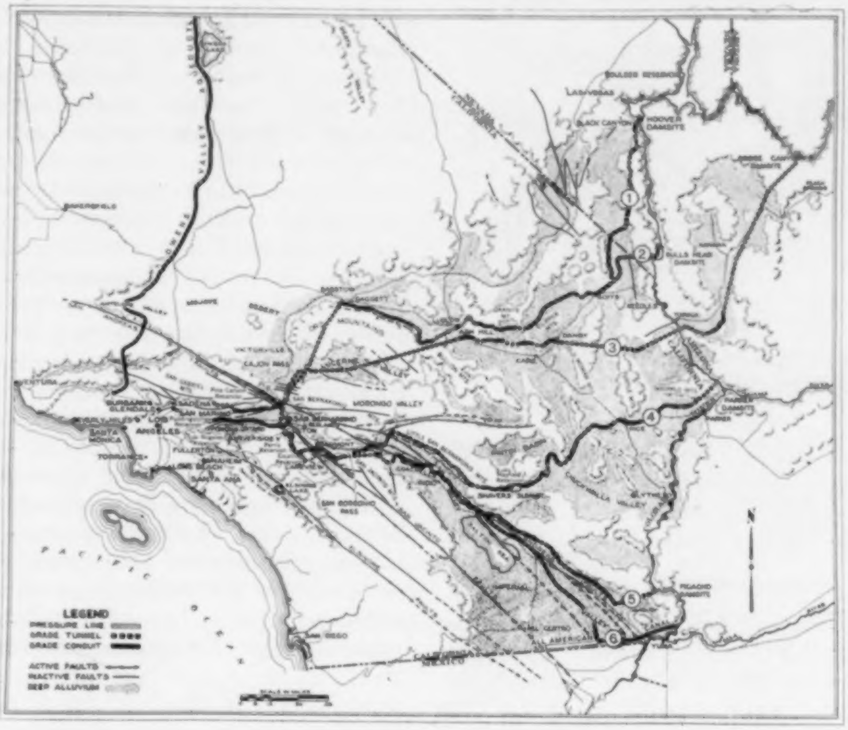


Fig. 2. The Six Routes Considered

THE BLACK CANYON LINE

Returning again to Fig. 2, it will be noted that diversions are possible from the river at Bridge Canyon, Black Canyon, Bulls Head, Upper Parker, and Picacho, or from the All-American Canal. A great number of line studies have been made from each of these points. The reservoir in Black Canyon offers an advantageous point for diversion. The water there is at a higher elevation than at other points farther down the river and, because of the large storage volume, would be of first class quality, entirely free from silt. The best location of a line from Hoover Dam is shown on the map, Fig. 2. This line leaves the reservoir in a short tunnel, after which it follows a contour location to a point near Daggett, where it enters a 50-mile tunnel, passing underneath the western end of the Bullion Mountains, under a portion of the Lucerne Valley, emerging from the San Bernardino Mountains near the city of San Bernardino. From this point it follows a reasonably easy location to Pine Canyon or other suitable reservoir.

The mean elevation of the water behind Hoover Dam in Black Canyon will be 1,167 ft. For convenience in distribution, a terminal elevation of at least 800 ft. is desirable, and 1,000 ft. is preferable. If excessive construction cost is to be avoided, a line as long as that from Black Canyon requires a drop of approximately 1,000 ft. to overcome friction losses. It is, therefore, evident that pumping would be required on a line from Hoover Dam.

If the water were brought through in a straight gravity tunnel, with a low terminal elevation, some flow might be taken from it directly for the areas near sea level. In this event, less pumping would be required than if the entire flow were lifted at the inlet end, but the actual reduction in cost of pumping would be small, because of the higher cost of power at the outfall. Furthermore, the land between the intake and the outlet is all high above any possible direct gravity flow line, and any such line would be wholly in tunnel. It would, moreover, be difficult if not impossible to construct, because it would pass at great depth through several of the deep detritus-filled valleys.

Although the cost of pumping varies with conditions, for the present purpose it may be stated that a sum of $80,000 is sufficient to build and forever maintain and operate the plant required to lift 1,500 sec-ft. one foot. Each time the aqueduct is raised one foot, it may be considered as being penalized by this sum. Within certain limits, lifting will bring the line nearer to the general level of the country and the cost will be reduced. Wherever a pump lift of one foot reduced the estimated construction cost by more than $80,000, the lift was considered to be justified.

Having decided upon a general elevation for the line, its cost then depends upon its slope. If the fall per foot is great, the velocity will be high and the conduit may be small. If the grade is flat, large tunnels and conduits are required and the cost per foot is great. The correct slope was also determined by the value of a foot of pump lift, and additional grade was utilized as long as the reduction in first cost was greater than the endowed value of the increased pump lift.

Taking all of these factors into consideration, a profile for the Black Canyon line was selected, as shown in Fig. 3. This line contemplates a total pumping lift of 1,663 ft. near the point of diversion. The resulting line is in good location, except for possible difficulties in the long 50-mile tunnel between Daggett and San Bernardino. The San Andreas fault is crossed on the surface under favorable conditions. A drop of 564 ft. at the terminus is available for the production of power.

THE BULLS HEAD LINE

As an alternative, it is possible to shorten the Black Canyon line by making the diversion at Bulls Head,

about 50 miles farther down the river. This plan necessitates the construction of a diversion and power dam at Bulls Head, the cost of which tends to offset the reduced length of line. The pump lift is higher than at Black Canyon, but this is partly offset by the power produced at the diversion dam. Taken all together, the estimates show this line to be slightly less

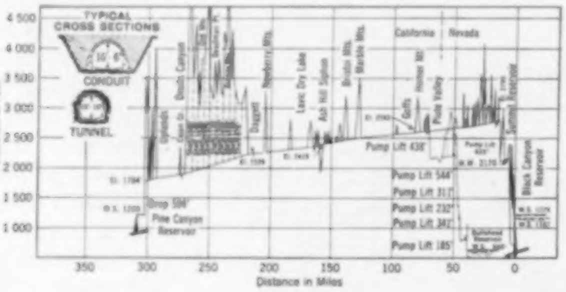


FIG. 3. PROFILE OF TENTATIVE BLACK CANYON LINE
Showing Bulls Head Alternate

economical than the Black Canyon line. A profile of the best Bulls Head line is also shown in Fig. 3. The total lift is 2,051 ft. and the power drop at the outfall is 564 ft., as in the Black Canyon line.

THE PARKER LINE

A diversion at the Parker site, still farther down the river, near Parker, Ariz., is likewise possible. The topography along this line permits of a lower summit elevation so that the total required pump lift is less than for the Black Canyon line, even though the diversion level is lower. The longest tunnel, moreover, will be only 13 miles as compared with 50 miles on the Black Canyon and Bulls Head routes.

For its full length the Parker line is in stable and safe location. After an initial pump lift of 539 ft. to an elevation of 989 ft., the Parker line (with dam) leaves the river in a 12.3-mile tunnel through the Whipple Mountains, of granitic formation and free from important faulting. Beyond this tunnel there is a length of 51 miles of surface conduit which may be of cut-and-cover conduit or open-lined canal. This section is located in granular detrital material, a product of disintegration of the native igneous rocks. It offers stable foundation for any type of lined surface channel. In its proposed location, the conduit through this region will be relatively free from any danger of disturbance by cloudbursts or earth movements.

The above mentioned length of surface conduit leads to a tunnel through the Granite Mountains, which will be mostly in solid rock, although some detrital material will be encountered at the portals. It is not expected that water will be encountered in these detrital approaches. Leaving the Granite Mountains, the aqueduct lies largely on the surface, with a few short tunnels, in stable material, to a point west of Shaver's Summit. In this stretch are located the pumping plants required to lift the water up to its final summit elevation of 1,817 ft.

At the base of the last pumping plant, just before reaching the summit, there exists a natural basin of large capacity, the Hayfield Reservoir, which can be developed at a nominal cost and is available for the equalization of flow or as a protection against possible breakage in case the surface conduit leading to it is of open-canal type.

West of Shaver's Summit, the line is located in a series of tunnels along the face of the Little San Bernardino Mountains. The tunnels are in a stable block of ancient rock which shows little if any important faulting.

Emerging from the San Bernardino Mountains, the line crosses the upper end of the Coachella Valley in conduit. The San Andreas fault and its important branches are traversed on the surface under conditions which insure reasonable safety against serious damage in case of movement. The line then passes underneath the San Jacinto Mountains in tunnel, emerging near the mouth of Potrero Canyon in Perris Valley, where the San Jacinto fault line is crossed at the surface. From this point the line may be led to the terminal storage reservoirs by either of several safe and satisfactory routes.

As shown by the map, this line could be shortened by moving the point of diversion downstream. This is impracticable because the river channel below Parker is not permanently fixed and a diversion from it would be precarious. At the proposed diversion, the river is confined between rock walls. The Parker site is favorable for the construction of a combined diversion and power dam. The height to which the water can be raised is limited by encroachment on the city of Needles, Calif., about 58 miles up the river. A dam raising the water 72 ft. to elevation 450 is contemplated. Foundation conditions at the site are excellent for any type of dam, except for the great depth of overburden in the river channel. This difficulty may be offset, in part, by deferring construction until after the river is under control at Hoover Dam.

The diversion may be made by pumping directly

SAN ANDREAS FAULT, NEAR SALTON SEA, FROM THE AIR
Characterized as the Most Important Fault in California if Not on the Entire Earth

from the stream, or a combined diversion and power dam may be constructed. The power producible at the site will pay for the dam. If the dam is not built, it will be necessary to install clarification works at the point of diversion. In this event, a low-head pumping plant will be provided to lift the muddy water into the clarifiers, and only clear water will be delivered to the

high-head plant. A profile of the Parker line, as at present projected, is shown in Fig. 4.

THE PICACHO LINE

The lowest practicable point of diversion from the river is at Picacho, about 20 miles north of Yuma, Ariz. It is contemplated that the water would be diverted by pumping directly from the river. This could be accomplished with safety at the selected site, as the river is confined between definite rock walls and has no opportunity to meander. A low diversion dam could be constructed, but its cost would be prohibitive. In any event, it would be necessary to install and operate some type of desilting equipment, as a storage reservoir capable of absorbing all prospective future silt accumulations is not feasible. The water would be pumped from the river through a height of 332 ft. to elevation 516 and delivered into a tunnel leading through the Picacho Mountains to the northern slope of the Imperial Valley. This tunnel would be partly in rock, thought to be of stable character, but toward its western end it would encounter an alluvial formation for a considerable distance.

After emerging from the first tunnel, this line skirts the northern rim of the Imperial and Coachella Valleys for a distance of more than a hundred miles, parallel to and near the San Andreas rift, as shown in Fig. 2. This rift is characterized by numerous side faults. According to Dr. Buwalda, "it appears to be inviting trouble to follow the San Andreas fault closely for long distances."

ALL-AMERICAN CANAL ROUTE

It is possible to eliminate the eastern end of the Picacho route by pumping from the western end of the Coachella branch of the All-American Canal, which, as shown in Fig. 2, follows the San Andreas rift even more closely than the Picacho line and is considered more dangerous.

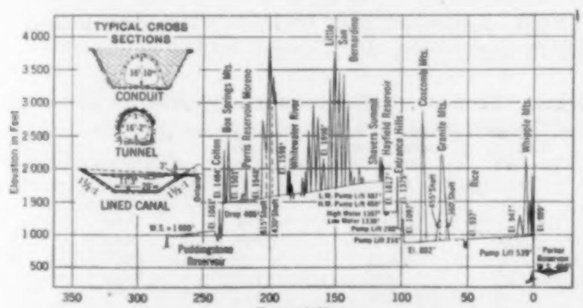


FIG. 4. PROFILE OF ADOPTED PARKER LINE

It is probable that a cooperative project would involve unavoidable operating difficulties, and it would probably be necessary that the All-American Canal and its branches be under full control of the irrigation interests. This would leave the Metropolitan Water District dependent for its supply upon the operation by an outside organization of a long irrigation canal. It would also be difficult to enforce necessary sanitary regulations along the irrigation channel.

Losses in an unlined canal through a sandy region like Imperial Valley would be tremendous. So the only way to make this project feasible, as regards losses, would be for the Metropolitan Water District to line the entire canal at its own expense. The practicability of such an arrangement is questionable.

THE BRIDGE CANYON LINE

Of the lines shown in Fig. 2, the Bridge Canyon line

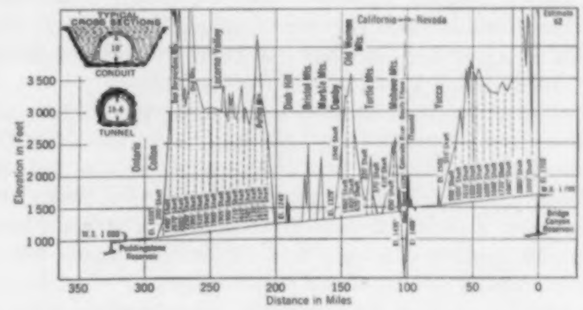


FIG. 5. PROFILE OF BRIDGE CANYON ALL-GRAVITY LINE

is proposed as an all-gravity route, delivering water into Puddingstone or other suitable terminal reservoir. This line requires a dam of from 600 to 900 ft. in height at the lower Bridge Canyon dam site, which site appears satisfactory for a dam of considerable height. The plan, as presented, contemplates the construction of the diversion dam by the district, on the assumption that the power developed will be owned and controlled by it. But it is improbable that such an arrangement could be perfected.

According to this plan, the aqueduct leaves Bridge Canyon in a tunnel 75 miles long under the Grand Wash Cliffs. As this tunnel lies at a great depth below the surface, shafts would be deep and construction of the tunnel expensive. Some of the shafts are located where the alluvial material and detrital valley fillings are of great depth and undoubtedly carry a considerable amount of water.

Emerging from the tunnel, the line passes in conduit to a point west of Topock, where it goes into a steel pressure line 4.9 miles long across the Colorado River, where the maximum head would be 1,025 ft. West of the river, it pierces the Mojave Mountains in tunnel and proceeds along a comparatively safe route, about 45 per cent in surface conduit, to a point near Ludlow, where it passes into a tunnel 89.5 miles long under the Bullion Mountains and beneath the water-filled Lucerne Valley, finally emerging at a point in the vicinity of San Bernardino. The outlet end of the tunnel is at a low elevation and for several miles is in the water-bearing gravels along the northern slope of the Santa Ana Valley. The San Andreas fault system is crossed deep underground by this long tunnel. This line, a profile of which is shown in Fig. 5, traverses a most difficult geological terrain.

The claim that water would ultimately be delivered practically without cost neglects the requirement for paying taxes on district property outside of California. The dam, the reservoir, and 105 miles of aqueduct would be located in Arizona. The cost and the operating expense of this line are much greater than for any of the pumping routes.

QUANTITY AND COST OF TERMINAL STORAGE

Investigations have shown that ample space for terminal storage near the outfall end of the aqueduct is available. There are several promising reservoir combinations from which a development may be chosen. Possibly the most convenient combination would be one including the Los Nogales Reservoir, which lies in the valley west of Pomona. Other promising reservoir combinations involve the use of either the Cajalco site, south of Riverside, or what has been termed the Perris site, near Lake View in the Perris Valley.

Terminal storage, located as near as possible to the delivery end of every long aqueduct, is a most desirable feature. Such storage not only serves to iron out the difference between the seasonal demands for water and the uniform rate of delivery through the aqueduct, but also enables the aqueduct to be shut down whenever necessary for repair or other purpose. The longer the aqueduct the more important does terminal storage become, and this Colorado River system is one of the longest aqueducts ever projected.

Terminal storage, moreover, is even more important for a system used for domestic supply purposes because of its effect in improving the quality of the water delivered for use. Still further, terminal storage is a direct insurance against the possibility of interruption along the entire aqueduct system which lies beyond the reservoirs.

A terminal storage volume equal to 30 days of aqueduct capacity would call for practically 100,000 acre-ft., and this quantity would reasonably serve all other purposes during the early years of the project. Terminal storage of 100,000 acre-ft. can be developed at a total cost of $17,500,000, on the basis of building the necessary dams so that later on they may be raised to provide additional storage as future developments require.

PARKER ROUTE SHOWS LOWEST COSTS

A summary of aqueduct cost estimates along the selected lines, together with certain pertinent physical data, is shown in Table I. Of all the routes studied in detail, the Parker route is clearly the most favorable. The main reasons for this conclusion are summarized as follows:

1. While the Parker route is less expensive in initial cost than any of the others except the Picacho and the All-American routes, it shows a smaller operating cost than either of these because of its lower pump lift, and it will furnish water to the district at less cost per acre-ft. than any other safe and satisfactory route.

2. From the viewpoint of the geology of the country, the Parker route passes through the best terrain, involves less hazardous construction than any other route, and will be the safest line to operate.

3. The Parker route is the only one on which it is practicable to provide intermediate storage. The location of the Hayfield Reservoir gives to it an advantage not enjoyed by any other route.

4. It is located entirely in California and is free from taxation or assessment in any other state. Water may be taken directly from the Colorado without interference with the rights of any other state.

5. The estimated ultimate cost of the Parker route, $220,535,000, is believed to be within the financial capacity of the district and is reasonable in consideration of the value of the service it will render.

6. The advantage of slightly lower initial cost of both the Picacho and the All-American routes is more than outweighed by the generally unfavorable terrain on both of these and the disadvantageous operating conditions of the All-American route.

The foregoing conclusions are also those of the Engineering Board of Review of the Metropolitan Water District. The Board, appointed to review the report of the Chief Engineer and to study the problem as a whole, consisted of: Chairman, Thaddeus Merriman, Chief Engineer of the New York City Board of Water Supply; A. J. Wiley, Consulting Engineer of Boise, Idaho; and Richard R. Lyman, Consulting Engineer of Salt Lake City. Its report, submitted on December 19, 1930, confirmed and endorsed the conclusions set forth in my report of November 14, 1930.

TABLE I. SUMMARY OF COST ESTIMATES, NOT INCLUDING TERMINAL STORAGE, FOR ALTERNATIVE AQUEDUCT LINES

PHYSICAL DATA	BLACK CANYON (1)	BULLS HEAD (2)	BRIDGE CANYON ALL GRAVITY (3)	PARKER, WITH DIVERSION DAM (4)	PARKER, NO DAM (DIRECT DIVERSION) (4a)	PICACHO (5)	ALL AMERICAN (6)
Height of diversion dam, feet	0	120	600	72	0	0	0
Initial elevation, feet	1,167	640	1,705	450	378	184	177
Terminal elevation, feet	1,220	1,220	1,000	1,000	1,000	1,000	1,000
Total pump lift, feet	1,662	2,051	0	1,523	1,601	1,997	1,888
Total power drop, feet	564	564	498	406	406	620	406
Pumping, millions of kw-hr. required per year	2,353	3,154	0	2,384	2,533	3,231	2,652
Longest tunnel, miles	51.33	51.33	89.51	12.95	12.95	15.34	12.95
Total length, all tunnels, miles	128.24	105.96	225.64	92.60	93.67	56.71	38.18
Total length, all pipe lines, miles	12.69	24.57	8.69	18.38	18.86	18.43	15.69
Total length of aqueduct, miles	299.40	254.01	315.90	265.36	266.91	234.12	271.44
Deepest shaft, feet	1,840	1,840	2,800	1,430	1,430	1,430	1,430
Total depth of shafts, feet	11,825	12,535	56,575	2,860	2,860	2,620	2,045
Years to construct	6	6	9	6	6	6	6
COST IN DOLLARS							
Preliminary investigations	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000
Head works	500,000	13,970,900	68,163,000	13,058,400	3,983,000	3,812,200	3,219,200
Aqueduct	194,529,000	163,051,100	370,977,000	144,423,700	145,942,100	132,836,800	117,334,800
Auxiliary storage	0	0	11,000,000	76,900	76,900	0	2,115,000
First Development (800 sec-ft.):							
Pumping plants	13,047,000	20,867,000	0	24,733,000	26,650,000	35,680,000	29,165,000
Power plants at diversion	0	705,000	11,004,000	516,000	0	0	0
Return power plants	2,286,000	2,306,000	0	1,100,000	1,100,000	5,027,000	2,878,000
Total construction	212,862,000	203,400,000	463,644,000	186,408,000	180,252,000	179,856,000	157,212,000
Total, including interest	239,006,000	227,346,000	557,846,000	206,279,000	199,442,000	199,180,000	174,265,000
Future development (1,500 sec-ft.)	9,724,000	15,768,000	4,284,000	14,256,000	14,112,000	15,552,000	13,320,000
Total capitalized, operation and maintenance	121,617,300	135,940,000	145,918,000	119,454,000	128,635,000	152,642,400	133,146,400
Capitalized return on power sold	0	0	55,095,000	0	0	0	0
Average perpetual cost per acre-ft.	23.35	23.95	39.99	21.60	21.82	23.34	20.30

Western Pennsylvania's Engineering Progress

Pittsburgh Reviews a Half Century of Achievements and Plans Its Future

By Morris Knowles

Member American Society of Civil Engineers

President, Morris Knowles, Inc., Consulting Engineers, Pittsburgh, Pa.

Nature has endowed Western Pennsylvania with her richest resources, and at the cross roads of industry and commerce lies Pittsburgh. This city could not be other than a center of engineering activity—water purification, bridge building, city planning, development of waterways, rail transportation, and highway engineering. In this article Mr. Knowles reviews the local engineering events of the last half century, many of which have come within his own experience. He notes changes in method from the period of trial and error to the present system of thorough study of, and intensive planning for, individual projects. This article is an abstract of a paper read by Mr. Knowles before the Engineers' Society of Western Pennsylvania on the occasion of its fiftieth anniversary, November 14, 1930.

The early history of Pittsburgh is inextricably linked with the history of the rivers and their development as improved waterways; their importance to the city has not lessened with time. Pittsburgh placed itself on record at the Sesquicentennial Exposition in Philadelphia in 1928, with the words of William Pitt:

"For as long as the Monongahela and Allegheny shall flow to form the Ohio, as long as the English tongue shall be the language of freedom in the boundless valleys which these waters traverse, Pittsburgh shall stand as the gateway of the West."

The beginning of the improvement of the Pittsburgh rivers was by private companies on the Monongahela River, and in 1841, tolls were first collected for passage through their locks. The original capital stock of the company which built the locks and dams was $300,000. When the Federal Government purchased the seven dams and eleven locks in the system, on July 7, 1876, it paid $3,761,643.

From Colonial days until the building of railroads, the Ohio River was the most important route into the West. Early work in aid of navigation on the river by the Federal Government was the removal of snags and the construction of contracting dikes at critical points. In 1879, Congress authorized the construction of a lock and dam five miles below Pittsburgh, the old Davis Island Dam.

This was the beginning of the canalization of the Ohio River, but the project whose quasi-completion has been so recently celebrated really did not have its inception until 1910, when Congress adopted 9 ft. as the navigable depth to be attained from Pittsburgh to Cairo by the construction of a series of low-lift, movable dams. This was the waterway of contemplated year-round navigation. The development of the Ohio has been along the lines of a comprehensive program in which each individual step contributed toward the completion of the whole.

Looking to Future Developments

Speaking on the occasion of the celebration of the completion of the Ohio River waterway project, President Hoover expressed the belief that "some day new inventions and new pressures of population will require its further development."

Its further development might mean the extension of its benefits by the construction of the canal to Lake Erie. The Pennsylvania Legislature and other agencies have sponsored surveys and investigations of this route. The preliminary surveys, which are demanded for this hundred-million-dollar project and which have been made, constitute a notable engineering work.

The further development of the river may take the form of stream regulation and the improvement of the river banks into usable river terminals. The history of river terminal development in Pittsburgh is a blank page. Industry has done its share but the City of

Pittsburgh Photo Engraving Co.

"Pittsburgh," November 25, 1758

The Point District a Half Century Ago

Pittsburgh and Allegheny County have been dilatory.

In 1911, the subject was directed to the attention of the district by the Pittsburgh Flood Commission as a twofold benefit combining wharf facilities and regulation of the river, with consequent protection from high water. Steps are now being taken, under the guidance of engineers of the Pittsburgh Department of Public Works and others, to develop river-rail terminals.

FLOOD COMMISSION MADE THOROUGH STUDY

The Flood Commission of Pittsburgh was organized in 1908, following the most devastating of Ohio Valley floods. This flood roused the people to action but their first intense interest lagged as time went on, and by 1912, after the Flood Commission had made its report and a bond issue was proposed to provide a flood wall which was part of the recommended plan of the Flood Commission, the people voted it down.

The Flood Commission's report was and is a tremendously valuable piece of local engineering study, and when flood control does come, as it surely will, the thorough study and investigations which are so necessary a prelude to any major work will, for the most part, have been done. It was in the broad sense an investigation of river regulation. As a direct result of the commission's activities, many streets in the down-town section and in the lower North Side have been raised above ordinary flood level.

Trinity Court Studio

PITTSBURGH TODAY—A CITY OF BRIDGES

EARLY RAIL TRANSPORTATION

Together with other cities, Pittsburgh has enjoyed the development of railroads in this country. In 1834, the Commonwealth of Pennsylvania opened its rail and water system from Philadelphia to Pittsburgh. In 1846, the Pennsylvania Railroad was chartered to build a line from Harrisburg to Pittsburgh, which was completed in 1854. The Ohio and Pennsylvania, later the Pittsburgh, Fort Wayne, and Chicago Railroad, reached Pittsburgh in 1852, established its station at Federal Street, Allegheny, and continued its headquarters at Pittsburgh.

It is interesting to note that even after those two railroads—one from the east and the other from the west—came to Pittsburgh and with some difficulty succeeded in entering the same railroad station in Grant Street, there was still no interchange of rolling stock, because at that time it was the policy of the states to present obstacles to interstate commerce. Ohio fixed the gage of her railroads at 4 ft. 10 in., while Pennsylvania made hers 4 ft. $8^1/_2$ in. As a matter of fact, it was not until a number of years later that cars of the Pennsylvania Railroad Company ever passed west of Pittsburgh.

With the extension of the railroads across the rivers, they came into physical conflict with the river interests, which claimed inadequate clearance beneath bridges and inadequate space between bridge piers for the free movement of cargoes. The political and controversial aspects of the situation dimmed the real railroading achievements of the last half of the nineteenth century and obscured the engineering accomplishments which conquered mountain and stream to link the East with the West in great systems of transportation. In view of the much greater mutual respect existing today between waterway and railroad interests, we may look forward to a closer alliance of these two agencies in the future through the medium of river-rail terminals.

ANOTHER RAILROAD COMES IN

After having Pittsburgh in view as a western terminal for many years, the Baltimore and Ohio Railroad finally overcame political and construction difficulties in 1871 to join with the Pittsburgh and Connellsville Railroad and gain access to the city, which was a rich traffic center. The flood of March 1913 destroyed the Baltimore and Ohio Railroad bridge at Zanesville, Ohio, and the Pittsburgh resident engineer of the road, the late Paul Didier, M. Am. Soc. C.E., accomplished a notable engineering work in the erection of a temporary bridge in the face of difficult high-water conditions.

The Pittsburgh and Lake Erie Railroad was the last of the three to enter Pittsburgh. Chartered in 1875, it was built and in operation by 1879. The Harmony Society of Economites was prominently identified with the road, and the present relation with the New York Central may be traced back to 1877, when, even before travel operations had begun, William H. Vanderbilt had become a trustee of the road.

MT. WASHINGTON BOULEVARD, DUQUESNE HEIGHTS
Liberty Bridge in Foreground

Railroads came to Pittsburgh in the rôle of long dis-

tance carriers and have remained to become great factors in the local transportation problem of the district. More than half of the trains entering and leaving the city daily are suburban and have their origin or destination from 15 to 45 miles away.

ELECTRIC STREET CARS AND RAPID TRANSIT

In Pittsburgh the original horse cars were followed, in 1887, by one of the first electric lines in the country. There was considerable doubt in the minds of railway engineers as to the relative advantages of cable and electric traction for street car purposes, and the experiment in Pittsburgh was a decided contribution to the establishment of the superiority of the electric system.

Boulevard of the Allies Along the Monongahela River
Grade Separation with Approach to Liberty Bridge in Foreground

It was long ago believed that the city had reached the limit in facilities for local traffic by surface electric railways and that the day was not far distant when actual operation would begin on routes either above or below the surface of the ground. One engineer advocated an elevated loop, and another proposed a subway.

In October 1916, the City Council authorized the appointment of a Transit Commissioner, E. K. Morse, M. Am. Soc. C.E., to investigate the subject and report on a means of obtaining rapid transit throughout the city and its suburbs. His report recommended that streets be widened, new arteries and boulevards provided, effective parking regulations enforced, street cars rerouted and finally, that a rapid transit line be established. Many of the recommendations have been carried out. Engineering studies have been continued under the City Planning Commission, and later the Transit Commission, under the chairmanship of George S. Davison, Past-President Am. Soc. C.E.

Moss Side Boulevard

In 1925, a report was made on a subway recommended for the first and second wards of the city, and the following year a plan was drawn up for its financing. Both of these reports were made possible by the 1919 bond issue of \$6,000,000 for subway purposes.

Aviation is the newest form of transportation to call upon the resourcefulness of the civil engineer. In addition to several large private fields, Pittsburgh has responded by careful study in the selection of a municipal airport site which it is developing on the Lebanon Church Road, where 400 acres are available for this purpose. Work is almost completed on the grading and drainage of the field.

ALLEGHENY COUNTY'S FIVE HUNDRED BRIDGES

An engineering contribution of no small importance in the rapid transit situation in Pittsburgh has been made by the many and beautiful bridges built in the district. Altogether, there are more than 500 bridges, railroad and highway, in Allegheny County. The first suspension bridge built was that which carried the aqueduct of the Pennsylvania State Canal across the Allegheny River, designed and built by the late John A. Roebling, M. Am. Soc. C.E., in 1844.

Built in 1912, the Larimer Avenue Bridge set a record in America for length of concrete span—312 ft. The Beechwood Boulevard Bridge, illustrated on page 381, won for John B. Stevenson, M. Am. Soc. C.E., the second prize in the 1929 Phebe Hobson Fowler Professional Award of the Society. The recently constructed Sixth Street Bridge won the award of the American Institute of Steel Construction for the most beautiful steel bridge built in 1928.

A COUNTY HIGHWAY PROGRAM

A rapid growth has taken place in the highway branch of the engineering profession. The demand for improved highways has required ingenuity and resourcefulness on the part of the engineers of western Pennsylvania who have undertaken this work.

In 1894, the Commissioners of Allegheny County were given power to assess taxes for the purpose of building and maintaining county roads. This was the first county in Pennsylvania to have such a program, and it anticipated the state's adopted policy by many years.

In 1924, a reorganization and financing plan was undertaken when the County Commissioners formed the Department of Public Works of Allegheny County and appointed Norman F. Brown, M. Am. Soc. C.E., its first director. The Liberty Twin Tunnels, a product of Pittsburgh engineering and construction skill, were, at the time of their completion in 1924, the first long, artificially ventilated tubes ever built in this country or abroad for the accommodation of automobile traffic.

Bigelow Boulevard, conceived by the late Edward M. Bigelow, M. Am. Soc. C.E., Director of Public Works,

was an early achievement in the construction of main boulevards. The Boulevard of the Allies, of more recent construction, and still later, the Mt. Washington Boulevard, contributed to the highway engineers' participation in the development of Western Pennsylvania.

BLAST FURNACES ALONG THE MONONGAHELA RIVER

The latest step in the development of Pittsburgh's highway system was the bond issue of June 26, 1928. This issue provided $10,930,000 for the construction of the Saw Mill Run Boulevard, the Allegheny River Boulevard, the Ohio River Boulevard, and the Moss Side Boulevard.

ACHIEVEMENTS IN SANITARY ENGINEERING

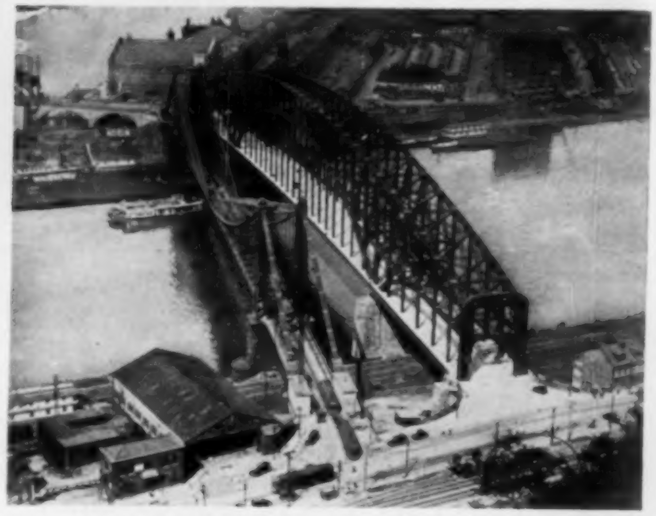
There is another branch of engineering which affects us in a much more intimate way, and that is water supply. Pittsburgh's history in this branch of civil engineering stands out among that of like cities the country over as the story of the conquest of disease and death. As far as the adequacy of the water supply is concerned, Pittsburgh's location on great rivers has again conferred a benefit on its citizens. But the quality of the supply is another story.

Deaths from typhoid fever in Pittsburgh from 1880 to 1890, ranged from 130 to 315 per year in a population that averaged 200,000 for the decade. The figures were higher than in other cities, even those using more highly polluted sources of water supply.

The late James H. Harlow, M. Am. Soc. C.E., a New Englander by birth, brought to Pittsburgh engineers in 1893 the import of the historic experimental work in sand filtration being done at Lawrence, Mass., under the direction of the late Hiram F. Mills, Hon. Am. Soc. C.E. Agitation among professional societies, including the local engineering society, led to the appointment by the mayor of Pittsburgh on June 8, 1896, of the Pittsburgh Filtration Commission "to investigate the effect of sand filtration and the advisability of establishing a sand filtration plant for the City of Pittsburgh."

The Filtration Commission brought to Pittsburgh the city's first sanitary engineers, who investigated not only the possibilities of sand filtration but also the question of bringing in another source of water supply to replace the Allegheny River. Their decision was, of course, as is now well known, to continue the use of the Allegheny River with a slow sand filtration plant. Pure mountain streams, usually deficient in quantity when the long-distance future is considered, were rejected in favor of the muddy waters of the Allegheny made hygienically safe and aesthetically attractive by sand filtration.

In 1899, the commission reported, and this report was followed by the development of detailed plans in accordance with its recommendations, and the construction of the filter plant. Typhoid fever death rates immediately fell. The death rate per hundred thousand population dropped from 125 in 1907 to 49 in 1908, to 25 in 1909, to 13 in 1910, and never again went above 20. In 1929, the rate was 2.3 per 100,000 including deaths of non-residents in institutions, one of the lowest rates in the country.



THE OLD POINT BRIDGE REPLACED BY THE NEW

That is the history of the modern water supply system of the City of Pittsburgh. But the water utilities of the Pittsburgh district employ other methods than that of slow sand filtration for purification, many of which represent notable engineering achievements.

The South Pittsburgh Water Company utilizes a modern water-softening plant. The Ohio Valley Water Company (now the Pittsburgh-Suburban Water Service Company) employs a still newer method of water softening, the zeolite process. The installation made by this company on Neville Island was one of the first of its kind. The Pennsylvania Water Company in Wilkinsburg has a rapid sand filter plant. Almost all the outstanding processes of water purification devised by engineering talent are represented in the Pittsburgh district.

A NEGLECTED FIELD

Another side of the sanitary branch of civil engineering, one closely allied with the subject of water supply, shows a disturbing absence of engineering achievement —the matter of sewage treatment. The subject has not been given the attention that other branches of engineering have received, even though many of the sewer designs, including tunnels and long trunk lines, are unique because of their difficulty of construction.

It has been a matter of statute law in Pennsylvania since 1905, that no city has the right to discharge untreated sewage into the streams of the state. The Purity of Waters Bill of that year exempted existing sewer systems from the penalties of the act, but the law

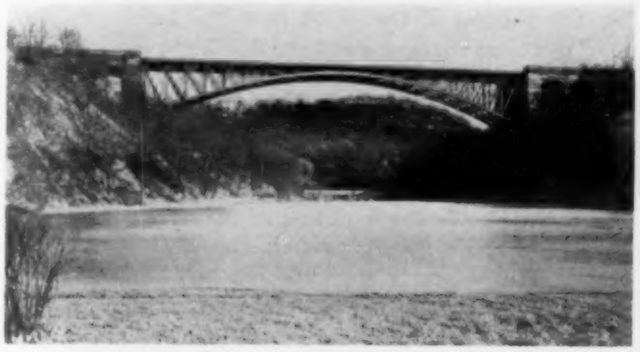
intended to prevent the wide extension of sewerage systems without treatment provisions.

It is to be hoped that, in the future, Pittsburgh will not lag in the development of this phase of engineering. The same kind of investigation that the Filtration Commission gave to the question of water supply should be given to this subject, so that Pittsburgh may contemplate its sewage disposal achievements with the same assurance it now feels in regard to water supply.

Comprehensive cooperation between state and local authorities in a thoroughgoing plan to dispose of all wastes and a vigorous insistence by the state upon the maintenance of more than minimum sanitary requirements, are needed to prevent further spoilation and to restore to some extent the original attractiveness of our water courses.

NEED FOR PLANNING RECOGNIZED

Pittsburgh's filtration system is typical of much that is done in engineering. It is a sound work based upon very thorough study and investigation. The actual work of the filters goes on underground where no one can see it; much engineering is of the same nature. Often the report of an investigation represents more of



Panther Hollow Bridge Connecting Boulevard of the Allies to Schenley Park

the actual engineering in a project than the more imposing construction that may follow. The history of engineering shows that it is through preparative study alone that we can arrive at the correct solution of the problem at hand. Given the solution in the form of a plan to be developed, a plan that reckons with the future as well as with the present, and we have an engineering accomplishment of the first magnitude.

Official recognition of the need for planning in municipal affairs led to the creation, in 1911, by the city government of a City Planning Commission. This commission prepared the Zoning Ordinance, which was passed by the Pittsburgh Council in 1923.

EARLY STUDIES IN CITY PLANNING

Even before the City Planning Commission was created the need for such an organization had been brought to the attention of the public by the activities of the Pittsburgh Civic Commission, appointed in 1909 whose purpose was "to promote improvement in civic and industrial conditions which affect the health, convenience, education, and general welfare of the people of the Pittsburgh industrial district."

The Civic Commission summoned to its aid men eminent in planning technic and, as long ago as 1910, published a report on a program for a city plan for Pittsburgh. This lay commission's appreciation of the importance of engineering in civic works was notable. The County Planning Commission was formed in 1918, and there is also a Citizens' Committee on City Plan, an entirely unofficial body of men who have expended nearly a quarter of a million dollars in engineering studies in the preparation of a plan for Pittsburgh.

PROGRESS IN ENGINEERING EDUCATION

Pittsburgh is yearly producing, in addition to engineering accomplishments, technically trained men who will assure a continuance of good engineering works. The first degrees in engineering were granted in 1848, at the Western University of Pennsylvania, the earliest institution of higher learning west of the Allegheny Mountains.

Its successor, the University of Pittsburgh, is at present constructing its Cathedral of Learning, a building unique in type among campus structures, and one of the engineering and architectural monuments of Pittsburgh. The Carnegie Institute of Technology, founded in 1900 by Andrew Carnegie, already has a large and distinguished alumni.

A FORWARD-LOOKING CITY

The history of Pittsburgh's accomplishments in civil engineering is replete with careful plans. Where these plans have matured into the works for which they were intended, we have a lasting confidence in those works. The city's history also reveals fields in which only plans have been made—plans which are awaiting fulfillment;

Beechwood Boulevard Bridge

it reveals fields in which not even plans have yet been developed.

It is a story of work done and work in progress. It is a story of the faithful and painstaking effort of members of the Engineers' Society of Western Pennsylvania. It is a picture of a city with major accomplishments to its credit and major improvements ahead. It reveals a percipient city, awake to the fact that its most successful accomplishments have only been attained after careful study, investigation, and planning, and preparing itself for the future by making plans now for the very much greater Pittsburgh of fifty years from now, at which time another history of fifty years progress in engineering may be written.

A Unique Bridge Over a Unique River

Unusual Combination of Difficulties Marks Railroad Structure in Louisiana

By C. D. Purdon

Member American Society of Civil Engineers
Consulting Engineer, St. Louis Southwestern Railway

THE vagaries of an illogical river, perverse foundation conditions, and a misbehaving bridge pier were boldly overcome by the ingenuity of the engineer when the needs of the railroad demanded the immediate completion of the bridge. Although these events occurred many years ago, the reminiscences of Mr. Purdon are none the less valuable in teaching their lesson to engineers today.

THE Atchafalaya River, in Louisiana, is a most remarkable stream. With no headwater drainage area, it begins on Old River or Shreves Cut-Off, originally a bend of the Mississippi, which was cut off in 1831 by a change in the channel. Starting full grown and getting its water from the Red River or from the Mississippi, whichever happens to be at the higher stage, the Atchafalaya runs through a low, swampy country with numerous bayous and lakes. On the map it looks like an artificial channel crossing these bayous because, when a bayou enters it on one side, another leaves it on the other. The wider stretches of the river are deep and the narrow stretches are shallow.

Its banks are low and unstable. During the high water period the soil becomes saturated, causing them to cave in and slide during low water. High water lasts from three to five months annually, with a variation of 26 ft. between high and low water at the point where the bridge was built. Fortunately for the construction work, the rate of change of stage is no greater than about 2 ft. in 24 hours.

An "oldest inhabitant" is credited with saying that the river has grown up within the memory of man. At one time it could be crossed on a foot log at a point near Simmesport, five miles below its source. At the same point it is now 650 ft. wide and 40 ft. deep at low water. The United States Government has placed two mattress sills at this point, entirely across the stream and up the high-water banks, to prevent the Mississippi from adopting this river as a new course, the distance to the Gulf being shorter, with a steeper slope, by way of the Atchafalaya channel. A description of some of the peculiar features of the Atchafalaya River has been given by the late J. A. Ockerson, M. Am. Soc. C.E., in Transactions, Vol. LVIII, page 1.

Starting the Bridge

In July, 1905, the Colorado Southern, New Orleans, and Pacific Railway, a subsidiary of the St. Louis and San Francisco Railway, began the construction of a bridge over the Atchafalaya River at Krotz Springs, La., about 12 miles below the Texas and Pacific Railway bridge at Melville. The bridge was to consist of a 300-ft. draw or swing span with fixed spans of 300 ft. at each end, and trestle approaches. Piers were to be of concrete, sunk by the pneumatic process.

Little work was done in 1905, as the rise of the river came early in the season, but on the return of low water, in 1906, work was resumed and continued until the usual rise. Good progress was made in 1907, and by November the sinking of the pivot pier was begun, the other four piers having been completed. The piers were sunk through strata of silt, blue mud, and sand. As the skin friction against them was very small, much trouble was experienced in keeping their weight light enough to prevent them from sinking too fast.

In November 1907, a movement was noticed in Pier No. 4, the pier at the west end of the draw span, caused by a slide about 800 ft. long in the west bank of the river. The effect of the slide reached almost to Pier No. 5. Movement was gradual and toward the east, amounting to 3.75 ft. in 18 days. Levels taken at the top of the pier showed that it was tipping eastward with no movement at the base.

In order to stop the movement, stone was dumped on the east side of it, dredging was begun on the west side to relieve the pressure, and cables were placed around the top of the pier and carried back to anchorages. A strain was placed on these in an effort to pull it back into position. This attempt only resulted in cracking the pier about 20 ft. above the base, and further attempts broke it again 14 ft. below the top. The total height of the pier, from top to base, is about 125 ft. Each crack occurred at the division between two days' work.

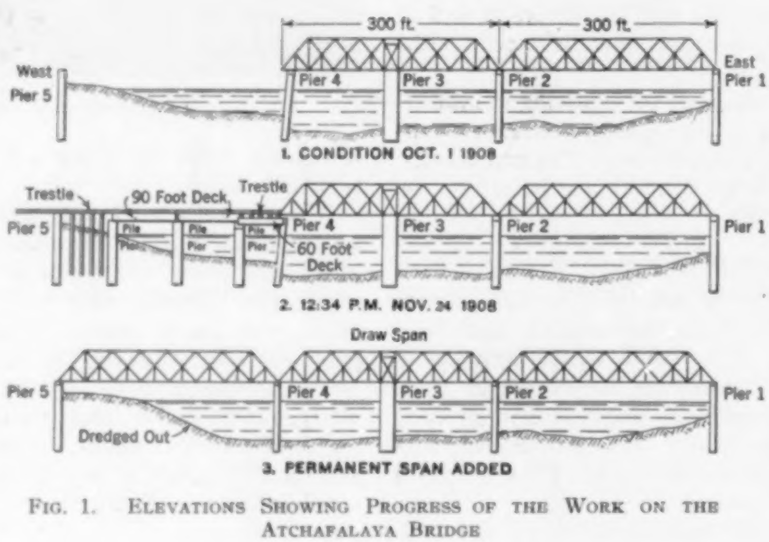


Fig. 1. Elevations Showing Progress of the Work on the Atchafalaya Bridge

The scheme of pulling the pier back into position was then abandoned and a plan devised for repairing it and using it in its

tipped position. This plan was to drive piling around it, close to its base, the heads of the piles to be about 50 ft. below the top of the pier. A steel shell, surrounding all the piles, was then to be lowered to the bed of the river and filled with concrete to within 35 ft. of the top of the pier. At this elevation the old pier was to be broken off and the new pier started in the proper position inside the shell. The piles had been driven and the shell ordered when the high water of 1907 stopped the work.

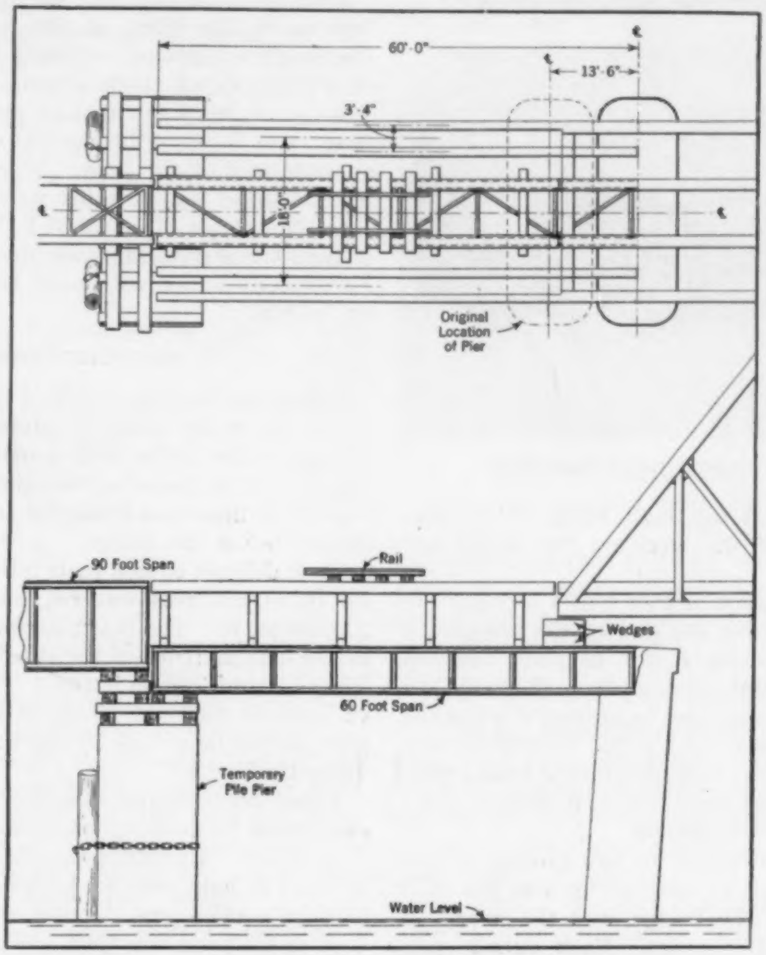


Fig. 2. Plan and Elevation of 60-ft. Temporary Span

During this time the east span had been erected and work had been started on the draw span. This span was erected in place on the center pier, without falsework, by balancing each member as it was placed by its mate on the other arm. As shown in the photograph, operations were carried on from a barge, which also carried the unbalanced load of the span.

In 1908, when work was resumed on Pier No. 4, a dock was built around the pier and erection of the shell was begun. When the shell was partly erected, another movement of the pier began, caused by the settling of the bank along the old line. This time the top of the pier moved more rapidly, reaching a total displacement of 13 ft. in a few days. The shell was then removed, as it became evident that some other plan of overcoming the difficulty would have to be adopted. The officials of the St. Louis and San Francisco Railway were notified that it would take at least another year to complete the bridge, according to the original plan.

New Methods Adopted

The bridge was the last piece of work to be done on the railroad, and there was too much money tied up in the line to allow a delay of another year. On September 28, 1908, I was instructed by President A. J. Davidson to visit the bridge and determine whether some kind of temporary work would make possible its immediate opening to traffic. Two days later, when I had decided that a temporary bridge could be opened but that radical changes in methods and organization would have to be made, Mr. Davidson telegraphed full authority to proceed with the work.

The steamboat *Lyon*, belonging to Kahman and McMurray, constructors of the substructure of the bridge, was still on hand, as was also the superstructure erection crew of the Union Bridge Company of Kansas City. Erection of the superstructure was in charge of Lee Treadwell, M. Am. Soc. C.E.

On October 1, I made an agreement with L. S. Stewart, President of the Union Bridge Company, of Kansas City, for the full use of his organization and equipment at the bridge, to be paid for at cost plus a fixed sum. The steamboat *Lyon* was rented and Messrs. Stewart and Treadwell remained on the work and were of great assistance in planning and advising. The Assistant Resident Engineer, E. N. Noyes, M. Am. Soc. C.E., who had been on the work in that capacity since it began, took charge of the engineering, as Resident Engineer.

Stopping the Movement of the Pier

The first thing to be done was to stop the movement of the pier and the obvious method was to wash away the bank which was pressing against it. Some attempt had already been made to do this, but a mattress which had been placed on the bank prevented the work being effective. The mattress was, therefore, removed. It was so thin that, by cutting it in strips about 100 ft. wide, the strips could be pulled off by the *Lyon*. While this work was under way, the largest suitable steam pump which was available in New Orleans was purchased and shipped by express to Melville where a barge was waiting to bring it to the bridge. This pump was set up on the *Lyon* and steam was supplied from the boat's boilers. A jet was kept working night and day on the bank to be removed.

Temporary Work Undertaken

When the pier stopped moving, 13.6 ft. out of position, the temporary work, which had been decided upon after many conferences, was begun. The railway had on hand three 60-ft., and two 90-ft. deck-girder bridges, which were sent to the site. The plan for the temporary work was to leave the east fixed span and the draw span in place, and to construct a temporary bridge in place of the west fixed span. The most easterly span of

the temporary bridge was to be composed of a 60-ft. deck-girder span, the east end resting on a shelf cut in the west side of Pier No. 4 and the west end resting on a temporary pile pier on the center line of the permanent bridge. The remainder of the temporary bridge was to be composed of two 90-ft. deck-girder spans resting on similar temporary pile piers, and about 70 ft.

ERECTING THE DRAW SPAN WITHOUT FALSEWORK

of pile trestle resting on the high bank. Elevations showing the progress of the work on the bridge are given in Fig. 1.

The easterly displacement of Pier No. 4 brought the end of the draw span over the end of the temporary trestle. It was therefore necessary to place the top flanges of the easterly 60-ft. deck girder sufficiently low to come under the draw span and to support it when the bridge was closed, as shown in Fig. 2. In constructing the easterly 60-ft. span, the buck and lateral braces were removed from two of the available 60-ft bridges, thus making available four 60-ft. girders.

These girders were arranged in two groups of two girders each. The center of each group was placed 9 ft. off the center line of the bridge, and the girders in each group were 4 ft. 4 in. apart. Each outside pair of girders supported the ends of the trusses of the swing span, as shown in Fig. 2. One of the photographs shows the method used in setting the outside 60-ft. girders and the short timber bents, which were built on top of the central girders to carry the tracks at rail grade, 7 ft. $4^{5}/_{16}$ in. above the normal top elevation of the piers. The 90-ft. girders were placed high enough to allow the ties to rest directly on them.

PILES ALSO USED

The three pile piers supporting the temporary span were each composed of 18 piles about 96 ft. long. Long piles were required for the mid-stream piers because the water was about 50 ft. deep and the mud was soft, as indicated by the piles in the trestle approaches on shore, which had a 42-ft. penetration. Piles 96 ft. long were procured easily, as the country was covered with good long-leaf pine and, if more time had been available, piles 100 to 110 ft. long could have been obtained. As the water was too deep to spike sway bracing to the piers, swaying of the piers was prevented by two crossed pine poles fastened diagonally across the two faces of each pier.

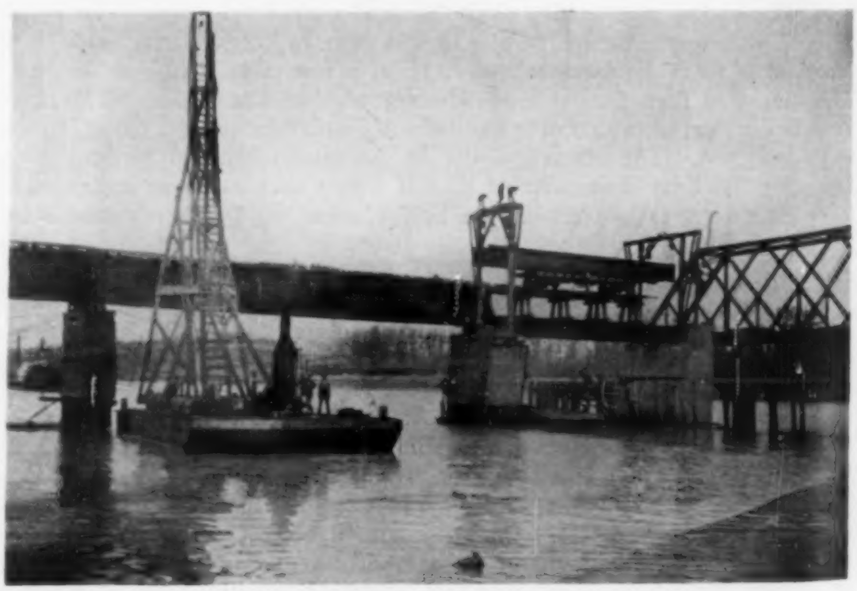
Each pole was placed by dropping one end of it to the bottom of the river, at the outer pile of the bent, the pole being guided vertically in its fall by two turns of a small chain taken around it and the outer pile. The top of the pole was then pulled over, clamping the chain, and fastened to the top of the outer pile on the opposite end of the bent. When the river was lower, plank bracing and sheeting were used.

On November 24, at 12:34 P. M., 55 days after I took charge, the first train, made up of the locomotive used by the contractors, with some box and flat cars, crossed the bridge.

PROTECTING THE WORK

A deep and narrow stretch of the river a short distance above the bridge made it advisable to cover the river bottom at the bridge with a mattress to prevent scour. The area to be protected was about 500 ft. wide, extending 250 ft. upstream above the bridge and 150 ft. downstream below the bridge. As the depth of the water made it difficult to sink mats into exact position, 223,024 sq. ft. of mattress was required to cover an area of 200,000 sq. ft. The best kind for this purpose seemed to be the crib mattress of the type used by the Mississippi River Commission on jetties. The size of the mattresses varied from the small 35- by 52-ft. size, used against the piers, to the large 134- by 136-ft. ones placed above and below the bridge.

These mattresses consisted of frames set 5 ft. apart, each frame made up of two 2- by 6-in. bottom pieces set 2 in. apart. Upright pieces, 2 in. by 4 in., and from $3^{1}/_{2}$ to 4 ft. long, were set between the bottom pieces and held by wooden pins. A row of sapling poles from 4 to 6 in. in diameter was then laid across the frames at upright angles and spiked to them. A second layer of



SETTING BEARING GIRDERS UNDER ENDS OF DRAW SPAN

poles on top, parallel to the frame, and a third layer, at right angles to it, were then laid. The tops of the frames, two 2- by 4-in. pieces blocked 2 in. apart, were then placed over the uprights, pulled down by a trade jack, and pinned with wooden pins.

Poles were procured on Turnbulls Island, at the head of the Atchafalaya, and the mattresses were built on launching ways and towed down to the bridge by the *Lyon*. The man who owned Turnbulls Island was to be paid for the poles by the cord. It was explained how they would be measured in the mat, but this did not suit him. He knew that a cord was 4 by 4 by 8 ft. and stakes had to be driven in two rows 4 ft. apart and the poles laid in them so that he could measure them.

Table I. Distribution of Costs in Making Mattresses

Item	Per Cent of Total Cost
Labor—handling rock, placing mats, and sinking	7.70
Rock and concrete ballast for sinking	17.27
Contractors' commission	13.04
General expenses	11.05
Getting started on the job	1.18
Unloading and moving material	1.28
Use of plant	10.92
Launching ways	1.28
Making mats	29.10
Towing mats	7.18
Total	100.00

Concrete for the riprap required to sink the mats was cheaper and could be more quickly obtained than riprap rock alone because the railroad had on hand a quantity of cement rendered useless for other purposes by rain. Satisfactory aggregate could be obtained from Profit Island in the Mississippi, whereas it would have been necessary to bring suitable riprap rock from points on the Ohio River. The concrete riprap was made on a leveled part of a sand bar by casting slabs 5 to 6 ft. square, set for four days, and then broken up into suitable sizes. The concrete was mixed in a proportion of one part of cement to twelve of aggregate. Both the mixture and the method of preparation proved quite satisfactory. The work of making and placing the mattresses was done by R. L. Van Sant, M. Am. Soc. C.E., under a cost-plus contract.

A Summary of Costs

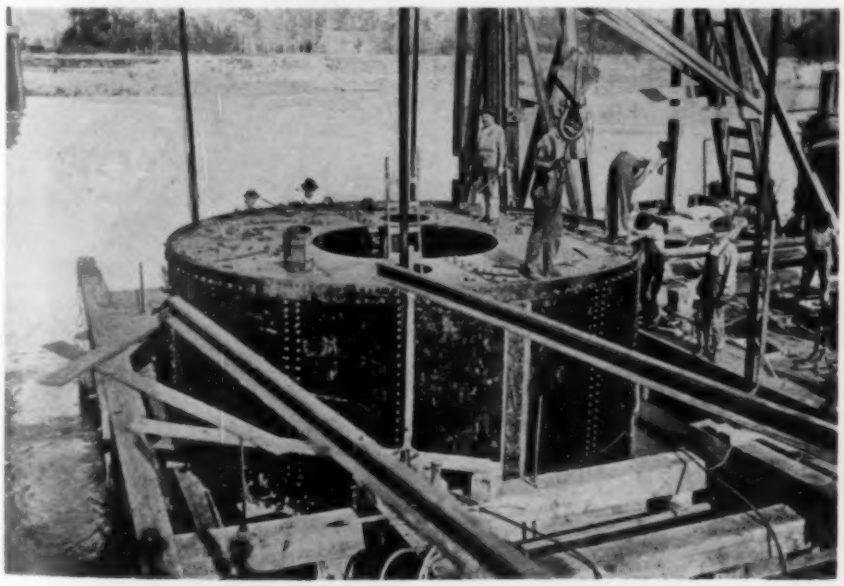
Expenses for mattress work vary so much under different conditions that costs on one job are of no value as guides in estimating other jobs. However, the distribution of costs among the items on this job may be of interest, and is shown in Table I.

Temporary Bridge Completed
Sinking Protecting Mattress

Recommendations for Permanent Work

While my connection with the project ceased with the completion of the temporary work, on leaving I made the following suggestions for the permanent structure. Two cylinders should be placed, one above and one below Pier 4, each cylinder to be 20 ft. in diameter below low-water mark, changing to 10 ft. in diameter above that level. These cylinders should support the end of the draw span and the 300-ft. fixed span by means of four 70-ft girders resting across the cylinders.

The inside of the lower portion of the cylinders should be hollow for a diameter of 10 ft., the outer space to be filled with concrete, and should be sunk, by open dredging, to a depth of 10 ft. or more below the old pier. Provision should be made for the use of compressed air in sinking the cylinders in the event that logs or drift should be encountered in the excavation.



Downstream Cylinder of Permanent Pier
Ready for Concrete

The Permanent Work

During construction, it was found unnecessary and impracticable to sink the two cylinders below the old pier, but in other respects the plan decided upon for the permanent work followed my recommendations. At first the sinking of the cylinders was slow on account of trouble from logs and other obstructions. After passing through the mats and drift, progress down to elevation −40 was about 3 ft. per day.

Then this rate was increased, and very rapid progress was made down to the landing elevation at −69, referred to approximate low water level as a datum.

As sinking progressed, there was some trouble from the movement of the cylinders to the north and east. This was serious for some time, but after considerable work the movement was stopped and the piers brought back to a good position. In order to bring the piers back to place, it was necessary to get outside the cutting edge to place cables, leading to the southwest, around the cylinders.

THE NOYES' DWELLING, ATCHAFALAYA RIVER BRIDGE

Since the area of the cross section of the channel was less than that desired by the company and Government engineers, it was decided to wash the banks on each side so as to give a larger waterway. This washing was also considered desirable to prevent further movements of the banks. It was recommended that the river be allowed to scour to certain depths at those parts not protected by a mattress and, when this depth was reached, further mattress protection should be placed to prevent scour below this depth.

In order to obtain the desired cross section, it was decided to erect an additional fixed span on the west, encouraging the river to deepen its channel under this span also. The additional span called for a new pier on the west shore. It was decided that it would be necessary to carry on the washing of the banks for several years, taking the deposit off the banks as the water receded.

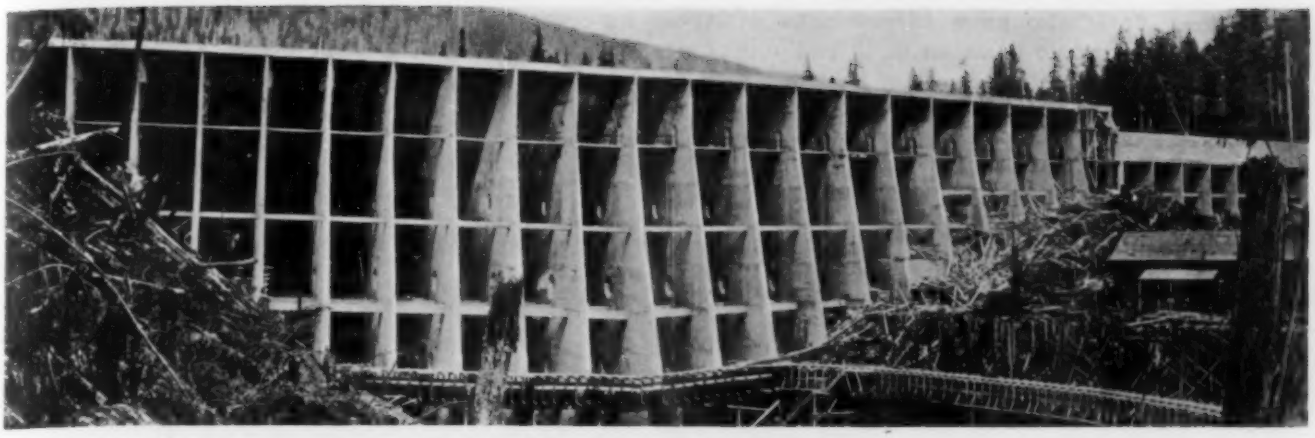
Plans were made for the cylinder piers and for the shore pier, plans for the additional span being the same as for other fixed spans. The contract for the work was let and work was begun as soon as the stage of the river allowed.

Information concerning the permanent work to replace the temporary spans has been furnished by Mr. Noyes, who remained to supervise that portion of the construction. As an indication of some of the undesirable living conditions an engineer and his family are required to put up with on work of this kind, a photograph shows the Noyes' dwelling, in February 1908. It was surrounded by 4 ft. of water a large part of the time.

From The Sydney Mail Annual

SYDNEY HARBOR BRIDGE, AUSTRALIA

This great steel arch represents another ambitious effort of the world's bridge engineers. It was erected entirely without falsework. Tied back to anchors at each end of the span, 128 cables, $2^3/_4$ in. in diameter, supported during erection the two cantilevered arms of the 1,650-ft. span until final closure was made on August 19, 1930. This bridge, containing 50,300 tons of steel, connects the city of Sydney with the North Shore. It will probably be opened for traffic within the year.



JORDAN RIVER DAM, BRITISH COLUMBIA
British Columbia Electric Railway Company, Ltd.

Recent Advances in Buttress-Type Dams

Scientific Use of Material Gives Marked Economy in Construction

By CALVIN V. DAVIS
ASSOCIATE MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
CHIEF DESIGNER, AMBURSEN DAM COMPANY, NEW YORK

SUCH great strides have been made in the development of steam power during the past few years that hydro-electric production has not been able to keep pace. Savings effected by better turbine design have not been sufficient to make up for losses from the uneconomical use of material in dams. However, great economies have recently been made possible by the development of several new structural types. Mr. Davis here describes two distinct types of buttress dams which will enable considerable savings to be made in the production of hydro-electric power.

As a result of past experience with existing high buttress dams combined with improved methods of stress analysis, there have recently been developed several new structural types in which great economies have been effected. A more scientific distribution of material has made these savings possible without sacrificing any element of safety. As a matter of fact, both higher and more consistent factors of safety have been attained in these new types than in the older types of dams.

Undoubtedly these new developments will affect to a large extent the economics of irrigation, water supply, and hydro-electric power developments. Comparative estimates for several large irrigation and water supply projects showed that the newer types would effect savings in cost of between 40 and 50 per cent as compared with the standard type of gravity structure. Without doubt, savings of this magnitude will make financially feasible a number of projects, the development of which has heretofore been considered uneconomical.

STRUCTURAL DESIGN SUPPLEMENTS MECHANICAL

Formerly most of the research for reducing the cost of production of hydro-electric power has been carried on by turbine manufacturers, and this work has been nearly all on the improvement of hydraulic machinery. The savings effected in this manner, while important, are not sufficient in amount to offset the losses due to the uneconomical use of material in the dam. For this reason, the development of hydro-electric power has not been able to keep pace with the development of steam power, in which great strides have been made during the past few years.

The trend of steam power development is clearly illustrated by the fact that the utilities have nearly doubled their output in the past seven years, with an increase in fuel consumption of only 32 per cent. Obviously, a major saving in the cost of the dam itself, which usually represents the greatest portion of the cost of the development as a whole, will have a marked effect on the development of certain sites which have heretofore shown less economy than would be obtained by the use of a steam generating station.

BUTTRESS TYPES DEVELOPED

As a result of these advances in structural design, two distinct types of buttress dams have been developed, characterized respectively by massive buttresses and by thin buttresses. In designs for the massive buttress type of dams—Figs. 1, 2, and 3—economy has been effected by spacing the buttresses relatively far apart and making them proportionally thicker in order to attain the required stresses. Dependence for stability is placed both on the weight of the massive concrete in the buttresses and on the water load on the deck.

The principal characteristics of the thin buttress type are: first, the use of both minimum buttress thicknesses and spacings; and second, the placing of a greater degree of dependence on the stabilizing effect of the water load on the deck than in the massive buttress type. An advantage of this type is that very low sliding factors may be obtained, which make it suitable for almost any

foundation. It is also more adaptable to dams of medium height and to dams on earth and other soft foundations.

On soft foundations, the limiting feature of dams is the span of the footing or floor slab between adjacent buttresses. A better foundation design is obtained by keeping the buttresses relatively close together, which would necessitate a thin buttress design. Notable structures of the thin buttress type are the Big Dalton Dam near Los Angeles and the Rodriguez Dam near Tijuana, Mexico. As seen in the photograph, the Big Dalton Dam, a structure 175 ft. high, is of the improved multiple-arch type. Of this type also is the Rodriguez Dam. This structure, 250 ft. high, of the standard Ambursen type, is now under construction. Among the photographs, selected at random from a list of nearly 250 Ambursen dams now in use, are typical high dams of the thin buttress type; also, for comparison, a view of the Coolidge Dam with its massive buttresses.

ROUND-HEAD BUTTRESS, A NEW TYPE

The principle of attaining economy through the use of wide buttress spacings has been applied to several types of designs. The most notable of these is the round-head buttress dam, Fig. 3, a design which has recently been developed by Fred A. Noetzli, M. Am. Soc. C.E.; the multiple-dome structure, of which the Coolidge Dam is a splendid example; and the Ambursen massive buttress type. A study of the diagrams and photographs will clearly indicate many of the important characteristics of these various types, which should be of interest to engineers.

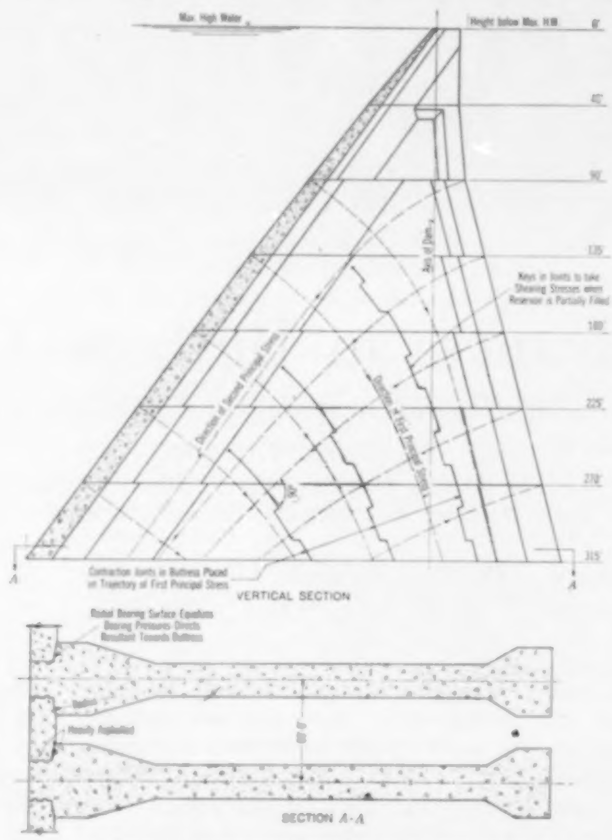


FIG. 1. TYPICAL AMBURSEN DAM, MASSIVE BUTTRESS TYPE
Buttresses Spaced 60 ft. on Centers

A round-head buttress dam has many excellent features, the most important of which are:

1. All water loads are transmitted in direct compression to the buttress through the massive cylindrical portion of the dam. The radial, water-bearing face, to which all pressures are normal, eliminates both bending and diagonal tension in the upstream portion of the dam.

2. The structural properties of this shape of buttress give an almost ideal distribution of principal stresses and shear throughout the dam.

3. All members of the dam are thick and massive, thus eliminating the objec-

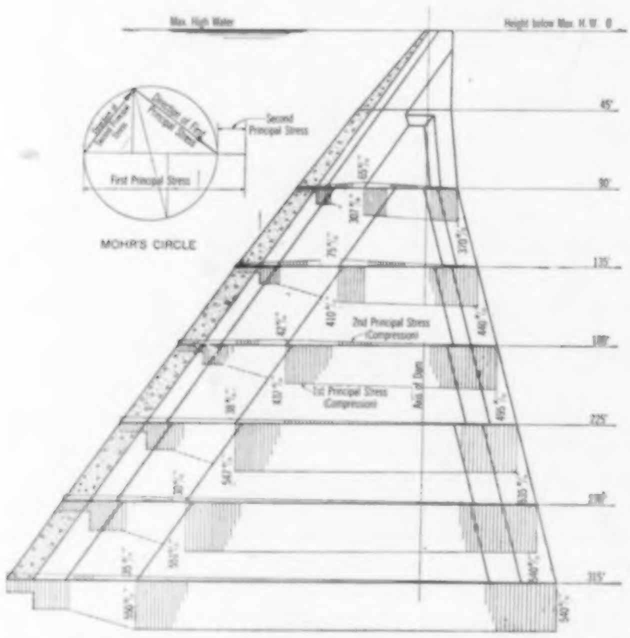


FIG. 3. TYPICAL AMBURSEN DAM, MASSIVE BUTTRESS TYPE
Intensities of, First and Second Principal Stresses

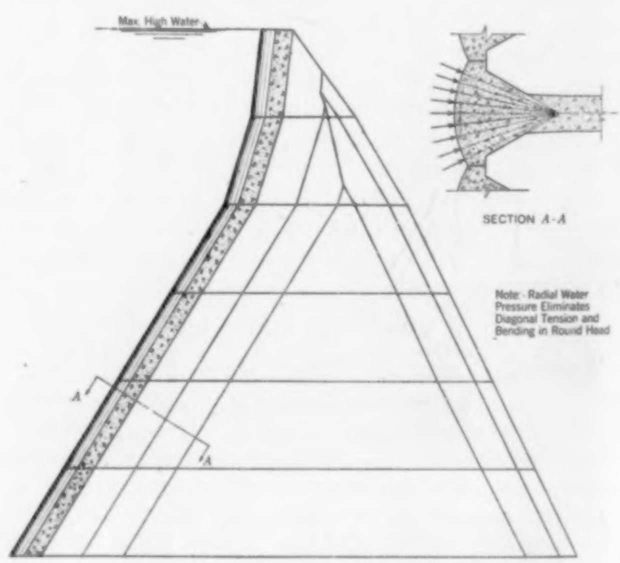


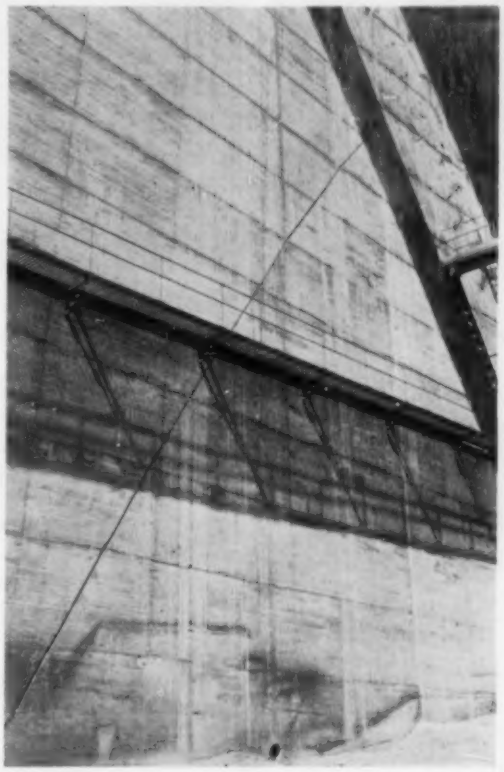
FIG. 2. SECTION THROUGH ROUND-HEAD BUTTRESS TYPE DAM

tions that some engineers have raised to dams with thin sections.

An illustration of how economy can be obtained through the use of wide buttress spacings is the Coolidge Dam, in which massive buttresses were used with a spacing of 180 ft. Comparative estimates showed that the multiple dome would cost somewhat less than the standard multiple-arch type at this site. While the multiple-dome type is very satisfactory for good foundations, it is a rigid structure and undoubtedly would not be suitable where foundations are faulted or where there is danger of earthquake tremors.

Big Dalton Dam
Los Angeles County Flood Control District

The Ambursen massive buttress type dam has practically the same advantages that are obtained in the round-head type, as many of the same principles are involved. Both types offer a high degree of flexibility owing to the positive expansion joints between the water-bearing units, and hence they are superior designs for yielding foundation conditions such as are found in earthquake zones.



Typical Contracting Joint
In Buttress of the Big Dalton Dam

STRUCTURAL ADVANTAGES OF MASSIVE BUTTRESS TYPE

As an example of how the scientific use of material gives both a saving in cost and better stress distribution, structural properties of the massive buttress type dam, shown in Figs. 1 and 2, may be compared with those of the standard gravity type. Let it be assumed that each dam is 300 ft. high. The base length for a properly designed gravity dam of this height would be approximately 260 ft. The first principal stress, or maximum inclined stress in compression at the toe, would be about 300 lb. per sq. in. and the first principal stress at the heel would be about 130 lb. per sq. in. The factor of safety against overturning would be slightly over two.

It will be noted that safety against overturning is a governing feature of the gravity design and that economy of material must be sacrificed to attain it. This is illustrated by comparing the factor of safety of slightly over two for overturning with the factor of safety of about seven in the strength of material in the same structure.

The massive buttress type dam, shown in Fig. 1, has a nearly uniform distribution of first principal stress of about 550 lb. per sq. in., which gives a material factor of safety of about four. This stress distribution also indicates that a maximum economy in materials has been approached. The stabilizing effect of water load on the deck makes economically possible the attainment of a higher factor of safety against overturning than is attained in the gravity dam. The design used for this illustration has a factor of safety against overturning of three. The volume of concrete in the massive buttress type is about one-third of that in the gravity type. The reduction in cost of the massive buttress type over the gravity type for this height would be between 40 and 50 per cent.

Another illustration of the economy that may be obtained through the use of buttress-type dams is given in Table I. In addition, it shows the relation between buttress spacing and quantities. It is difficult to formulate any rule governing the selection of buttress spacing for a given site, as the characteristics of every site are different. Generally, however, the economic buttress spacing is an increasing function of height.

STRESSES MORE UNIFORM

It will be observed that the large reductions in material have been accomplished through the use of improved structural sections which have conservative stresses, with more consistent factors of safety, and which have also retained practically all

Table I. Comparison of Quantities in Cubic Yards per Linear Foot of Dam

Height in Feet	Gravity Type	Massive Buttress Type			Thin Buttress Type
		Round-head Buttress, 60-Ft. Ctrs.	Ambursen Buttress, 60-Ft. Ctrs.	Ambursen Buttress, 40-Ft. Ctrs.	Ambursen Buttress, 30-Ft. Ctrs.
100	170	135	80	54	46
200	653	340	260	197	205
300	1,450	650	600	573	590
400	2,570	1,100	1,170	1,170	—

of the desirable features of the gravity type. Another advantage is the maintenance of a practically uniform ratio between horizontal shearing stress intensity and

vertical normal stress intensity. The relation $\frac{\Sigma H}{\Sigma V}$, ordinarily taken as a measure of the safety of a dam against sliding, takes no account of the distribution of the loading included in these summations.

For example, the average value of 0.75 for $\frac{\Sigma H}{\Sigma V}$, ordinarily used for a dam on sound rock foundation, may not indicate at all the safety against sliding, as a large portion of the horizontal or shearing force may be concentrated near one end of the foundation. I have found it relatively easy to maintain both uniform foundation pressures and uniform horizontal shearing stress intensities in designing the several kinds of massive buttress-type dams. This may be accomplished without sacrifice of economy and, in addition to obtaining uniform sliding resistance on the foundation, the tendency toward unequal settlement is eliminated.

Aside from the development of the types mentioned above, the most noteworthy advances in the design and construction of buttress-type dams have been, first, the improved methods of stress analysis; and second, the development of a system of buttress construction and contraction joints.

Modern methods of stress analysis, as applied to gravity dams, were introduced in this country about 20 years ago by Professor Cain. In more recent years his methods have been modified and adapted to the design of buttress-type dams. Probably the most important result of this has been a clearer understanding of the manner in which loads are transmitted from the water-bearing member, or deck, through the buttresses to the foundation. This has been possible through a study of the principal stresses and their directions.

RODRIGUEZ DAM
Tijuana, Lower California

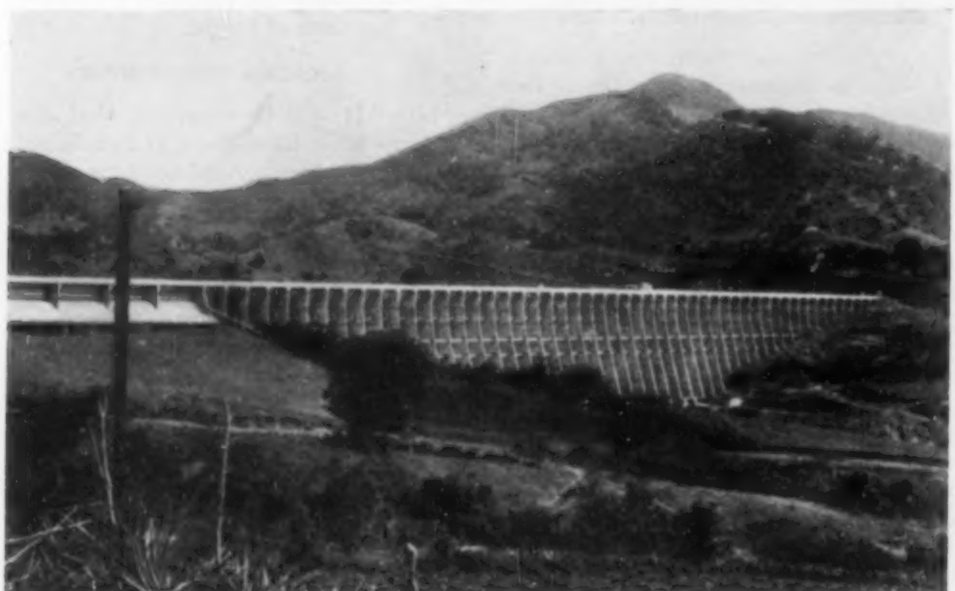
GRAND LAKE DAM—NEWFOUNDLAND
International Paper Company

CURVED COLUMNS COMPOSE BUTTRESSES

It has been observed from the stress analysis of buttress type dams that the directions of principal stresses follow definite mathematical laws. In general, the trajectories of first principal stresses are normal to the upstream buttress face and asymptotic to the downstream buttress face. The direction of the second principal stress is at any point normal to the direction of the first principal stress at that point.

These laws are illustrated by Figs. 1 and 2. Figure 2 shows the magnitude of the first and second principal stresses as determined for a typical massive buttress type Ambursen dam; Fig. 1 shows the directions of the principal stresses given by Fig. 2.

From the foregoing it may be concluded that a buttress is divided into a series of inclined, curved columns, each of which is transmitting a portion of the load to the foundation. These columns are de-



GUAYABAL DAM—U.S. GOVERNMENT, PORTO RICO IRRIGATION SERVICE

fined by planes through the trajectories of principal stress, which are also planes of zero shear. This has a very important bearing on certain features of design which will be mentioned later.

A more thorough knowledge of stress distribution has been directly responsible for the development of an improved system for placing construction and contraction joints in high buttresses. In laying out a system of contraction and construction joints for a buttress it is desirable, first, to retain the monolithic action of the buttress as a whole; and second, to place the joints in such positions that there will be no tendency for relative movement of either of the buttress sections separated by the joint. Construction joints and contraction joints form planes of weakness which are not capable of resisting shearing stress. Great care should be taken, therefore, to place both types of joints in planes of zero shearing stress intensity, or planes parallel to the trajectories of first principal stress when the dam is under full load, thereby causing no weakening of the buttress as a whole.

Inclined joints located in a buttress, as described above, will coincide with a trajectory of first principal stress only when the reservoir is full. As the reservoir is lowered, there will be light shearing stresses developed across the joints. It is advisable to provide for these stresses by the use of shear keys, as illustrated in Fig. 1.

To date there have been two high buttress type dams constructed in this country in which inclined buttress joints have been successfully used. These are the Coolidge Dam in Arizona and the Big Dalton Dam for the Los Angeles County Flood Control District. One of the photographs, giving a side view of a Big Dalton buttress, clearly shows an inclined joint. Inclined joints are also being used in the buttresses of the Rodriguez Dam, now under construction. The idea of inclined buttress joints was originally proposed by Mr. Noetzli. This is doubtless an outstanding contribution to the advancement of high dam design.

Experience has proved that high buttress type dams may be constructed with both safety and economy. The selection of design is dependent on engineering judgment as to its adaptability to the site in question and on the physical characteristics of the site. The matter of selection has been influenced in the past largely by precedent and in consequence there has been considerable waste due to the unscientific use of material. Now that precedents of successful performance have been established for the newer types, there is every reason to believe that advantage will be taken of their superior structural and economic features and that, in consequence, the rate of hydraulic development will be greatly accelerated.

Stony Gorge Dam—U.S. Reclamation Service
Orland Project, Calif.

Comerio Dam—Porto Rico
San Juan Railway Light and Power Company

Coolidge Dam, Arizona, U.S. Indian Service

Safeguarding Industry Against Fire

A Century of Progress in Fire Protection Engineering

By H. E. Magnuson
Providence, R.I.
Formerly Engineer and Editor, Associated Factory Mutual Fire Insurance Companies

Conflagrations are extinguished by professional fire fighters whose work is performed under difficulty and danger. However excellent their work, it is necessarily accompanied by property losses. The magnitude of the property loss is usually a measure of the work done. Conflagrations are prevented by the engineer who, through proper design, construction, protection, and elimination of hazards, can avoid all property damage and can assure uninterrupted operation to protected industries. This article, presented by Mr. Magnuson as an address before the Brown Engineering Association at the Boston City Club, on March 27, 1930, deals with the development of fire protection principles and methods and cites examples of their successful application. It is of particular value in pointing out practical methods for securing immunity from fire damage.

ENGINEERING as a science goes far back into antiquity; fire protection engineering, as a definite branch, is only about a century old. This branch of engineering, although a specialized study, is broad in scope, calling upon engineers in other fields for the knowledge they have built up. It calls upon the hydraulic engineer for the design of adequate public water systems and for data on the flow of water through mains, sprinklers, and hose streams; upon the mechanical engineer for the design of fire protection devices; upon the structural engineer for the safe design of buildings, tanks, and trestles; upon the electrical engineer for safe standards of construction, installation, and maintenance of electrical devices; and finally, upon the chemical engineer for data on the hazards and characteristics of the many chemicals which are used today in industry.

It may fairly be said that any great work is founded upon an idea. The first really practical application of the idea of fire prevention and protection originated with Zachariah Allen, the owner and operator of a woolen mill near Providence, R.I. At an early period in American industry, he clearly saw the vital importance of fire prevention and protection in safeguarding his plant and in helping to assure the future of his business. In his mill he provided the fire protection devices available in that day, taking particular care to maintain conditions of cleanliness and to eliminate hazards.

EARLY STEPS IN FIRE PREVENTION

He felt that such work deserved a lower rate of insurance and applied for one but was refused. He then interested other manufacturer friends, who soon saw the vital importance of his idea, and this community of interest led, in 1835, to the formation of the Manufacturers' Mutual Fire Insurance Company, for the purpose of providing insurance at cost on a mutual plan, and of making a practical study of fires and their prevention. The prevention of loss rather than simply distribution of loss was the fundamental principle.

Since then, other associated mutual insurance companies specializing in industrial properties have been formed, and this early linking of insurance with fire prevention and protection developed into a constructive endeavor which has been of great benefit to industry and, in its broader applications, to the country at large.

In those early days there were no adequate means of fighting fire and no scientific knowledge of hazards, so that the only weapon for preventing loss was the care and interest of far-sighted manufacturers cooperating in a joint effort. This factor of care, of primary importance then, is still vital today, and the interest of industrial managements is the underlying motive which makes fire prevention work practical and possible. Care and interest are intangible factors, which have remained unchanged. In the development of fire protection engineering we must trace progress along its physical lines—construction, protection, and occupancy. These can be discussed and can be explained with the aid of pictures such as the accompanying illustrations, which were supplied through the courtesy of the Inspection Department of the Associated Factory Mutual Fire Insurance Companies, from the files of the department.

Zachariah Allen's Worsted Mill, Providence, R.I.
Industrial Fire Protection and Prevention Originated Here Nearly a Century Ago

Considering construction first, the early mills with their massive stone walls give an impression of stability and safety against fire, but this impression soon disappears with a glance at the interior of a typical attic under the mansard roof common in those days. Light joisted construction was prevalent, often with many light wooden braces, the whole forming a great amount of combustible

material through which fire could spread rapidly, and having inaccessible corners and channels into which hose streams could not reach effectively.

In such a structure sprinklers cannot give effective ceiling distribution under joists; fire burns more readily because of the greater proportion of edges and vertical surfaces; and deep charring soon weakens the joists and causes collapse of the roof or floor. The disadvantages of this form of construction were overcome with the growing use of plank-on-timber, or slow-burning mill construction. With this plank-on-timber construction, shown in Fig. 1, the flat ceiling surface in the bays permits more effective distribution of water from sprinklers and hose streams, and even deep charring does not appreciably weaken the strength of the timbers. A large majority of the modern textile plants and many other industrial buildings are standing today as monuments to this improved type of construction.

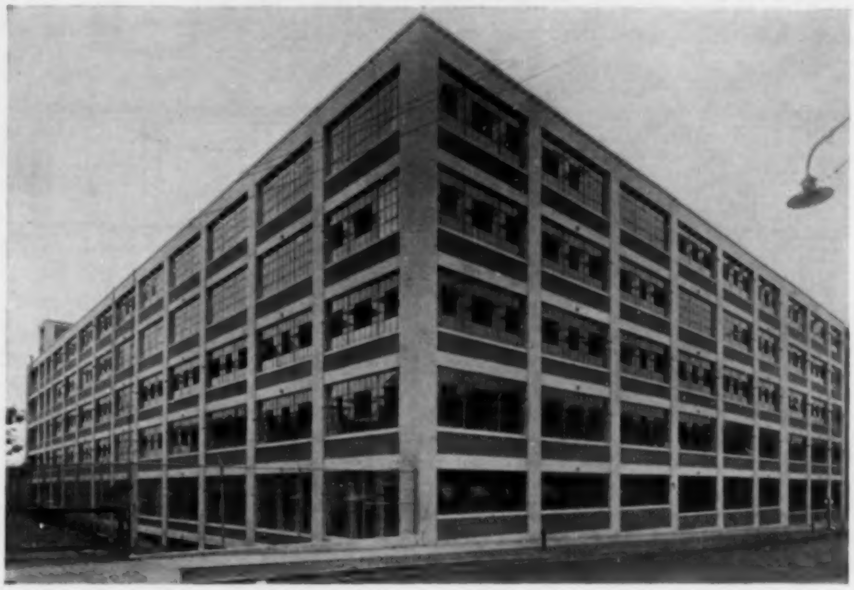
FIREPROOF CONSTRUCTION

Thoroughly non-combustible construction is comparatively recent. Reinforced concrete buildings particularly are becoming more and more common for factories and are improving the general average of industrial plants as fire risks. Steel-frame buildings with flat or corrugated sheet-steel sides and roofs are now quite generally used for smaller buildings and storage sheds and, from the fire standpoint, are an improvement over the frame structures formerly often used.

Non-combustible buildings are not necessarily fireproof. They do not protect combustible contents and may themselves be seriously damaged by the heat of a fire. A number of years ago a fire gutted several large unsprinklered reinforced-concrete buildings at the Thomas A. Edison plant in West Orange, N.J., completely destroying the contents and seriously spalling and cracking the concrete, showing typical damage which might occur without protection.

Water Test for Industrial Fire Protection
New Bedford, Mass.

Steel members likewise are vulnerable to fire, since they lose their strength when heated, causing collapse. A curious example of this was shown in another fire, in a building where steel I-beams and timbers had both been used to support the floors. As a result of the heat the steel beams weakened and collapsed, while the timbers, although they were deeply charred, still retained sufficient strength to support the floor above.



Typical Reinforced Concrete Industrial Building
Fafnir Bearing Company, New Britain, Conn.

FIRE PROTECTION THOROUGHLY DEVELOPED

The developments in protection against fire have been marked. The early mills had only fire pails, inadequate hose, and limited water supplies, usually a mill-use pump or small gravity tanks in the attic or on the roof. As the mills grew in size, as machinery was speeded up, and as new processes were introduced, the need of better protection became apparent. The first big step was the introduction of perforated pipe sprinklers, consisting of lines of piping suspended along the ceiling, fed by risers outside the building, and controlled by valves usually located in a detached valve house in the yard.

These systems were of some value and extinguished a number of fires but they had two serious drawbacks; first, when water was turned on they deluged the entire floor of a mill regardless of the extent of the fire, causing unnecessary water damage; and second, the small holes in the piping were likely to become clogged with scale or foreign material in the water, rendering the protection ineffective when most needed.

A natural outgrowth was the development of automatic sprinklers, the first installation of which in an industrial plant was made 55 years ago in a Fall River cotton mill. Fear of premature opening of the heads, with consequent water damage, at first prevented their general adoption, but as the heads were improved and as experience proved their value, their use grew quickly. Only the manufacturing rooms, with their hazards of running machinery, were at first protected. With time,

these sprinklered manufacturing rooms showed a better fire record than unsprinklered storehouses and other buildings of slight hazard, so that finally the sprinkler protection was extended until today it covers practically all parts of high grade industrial plants wherever there is any combustible construction or occupancy of value.

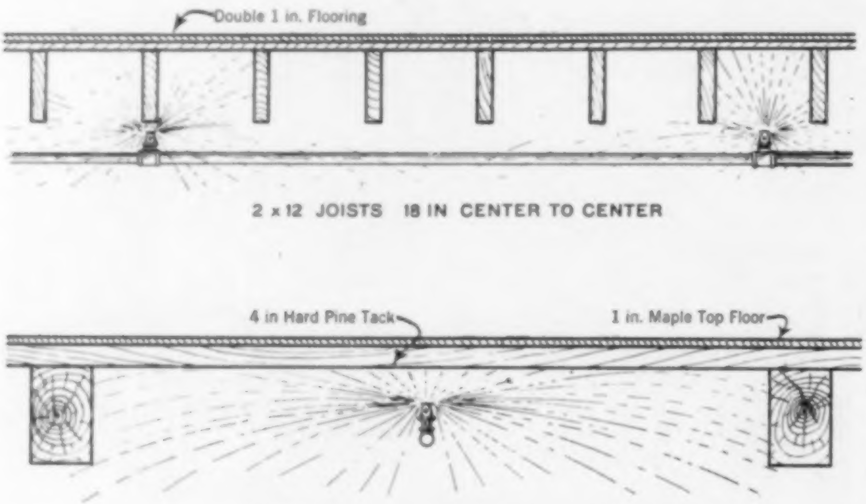


FIG. 1. AUTOMATIC SPRINKLERS MORE EFFECTIVE WITH "PLANK-AND-TIMBER" CONSTRUCTION

Automatic sprinklers are undoubtedly the greatest single factor in reducing industrial fire losses. A sprinkler system may be likened to a host of watchmen, one every 10 ft. throughout a plant, on duty day and night, year in and year out, each with a hose in his hand, ready to turn it on as soon as the first small blaze appears, remaining at his post in spite of heat or smoke, delivering water at the very seat of the fire. By comparison, the often blind groping of hose streams from outside is relatively ineffective.

WATER SUPPLIES ALWAYS IMPORTANT

Automatic sprinklers are of no value unless backed by a reliable water supply, which must be adequate both in pressure and capacity. Private fire protection systems are fed from public water systems, gravity tanks, private reservoirs, or fire pumps taking suction from rivers, ponds, or cisterns. All but the very small plants usually have two or more independent supplies, principally so that at least one supply will be available in case the other is temporarily crippled.

As a result of the needs of fire protection, many large plants now have strong private water supplies. In some cities, mills with adjoining yards have interconnected their systems and thus made the combined water resources of all available for a fire in any one mill. At New Bedford, one such joint system is supplied by city mains and 12 Underwriter pumps. In a test, these pumps delivered 14,000 gal. a minute, supplying 43 hose streams at 90 lb. pressure. A similar joint system at Lowell is fed from a private reservoir, city mains, and 12 fire pumps. One at Lawrence is supplied by city mains and 25 fire pumps.

SPECIAL MENACE OF PULPWOOD FIRES

One of the most interesting special problems in protection is the safeguarding of pulpwood piles at paper mills. Some of these piles formerly contained hundreds of thousands of cords, with values at times approaching a million dollars, all subject to destruction by a single fire. During wet weather or when the interior of the pile is frozen with snow and ice, it may be possible to extinguish a fire, if discovered promptly enough, with ordinary hose streams. In dry weather, however, a fire on the surface of the pile quickly drops sparks and embers down into the crevices where the fire soon obtains a stubborn hold beyond the reach of water, turning out great volumes of heat and burrowing inward, in this way destroying the entire pile in spite of ordinary good methods of protection.

Long and intensive study showed that, in order successfully to control fires in pulpwood piles, it is necessary to deluge the fire as soon as discovered with large quantities of water. To make this possible, fire protection engineers devised monitor nozzles which are fed by large mains backed by an ample pumping capacity. These nozzles throw far-reaching streams and deliver three times as much water as an ordinary fire hose. The nozzles are arranged generally on elevated towers at intervals around a pile and are supplemented by hydrants. They can be turned on quickly by opening a valve and do not involve costly delay in laying hose streams. A modern fire protection system of monitor nozzles at the Canadian International Paper Company at Three Rivers, Quebec, in a recent test delivered 5,000 gal. per min. from seven nozzles. Such a performance is another example of the way in which engineers have contributed to progress in fire protection.

MONITOR NOZZLES PROTECT PAPER MILL LOG PILE
Canadian International Paper Company, Three Rivers, Quebec

CONTROLLING EXPLOSION DANGERS

Occupancy is the third factor in the development of fire protection engineering; it refers to the processes and storage within buildings, their arrangement, hazards, and relative susceptibility to fire and water damage. The segregation and control of hazardous processes is a constant problem, since new and speedier methods of manufacture are continually being introduced. The nature of this phase of the work can best be illustrated by considering a few of the problems which have been met and solved.

Explosions are really very rapid combustions and are therefore similar to fire. Certain occupancies and processes have very definite explosion hazards which must be guarded against. These explosions may be of two kinds, dust or vapor. The dust explosion hazard is present, among other occupancies, in grain elevators and starch mills, and the prevention of explosions requires adequate cleaning so that there will be no possibility of dust clouds forming, and also the elimination of sources of ignition such as open flames, mechanical or electrical sparks.

Even with the best efforts at prevention, explosions occasionally occur and, in order to prevent building damage, a system of automatic venting has been devised which automatically relieves the pressure of the explosion before it builds up to the point where it can tear the building apart. Automatic venting windows designed along this principle quickly released the pressure without damage in an explosion in a Montreal grain elevator, while ordinary windows with steel sash in the same building were completely wrecked. In enclosed dusty processes, such as hard rubber grinding, the possibility of explosions has been largely eliminated by using inert gas from the boiler flues so that there will be no air or oxygen present to form an explosive mixture.

AFTER A DUST EXPLOSION
Ordinary Windows Damaged, Automatic Windows Undamaged

Vapor explosions are another type of hazard. Fire protection engineers obtain information in regard to these and other hazards from three sources: actual experience, laboratory research and study, and practical tests on a large scale. At the Factory Mutual Testing Station in Everett, large-scale tests in an explosion chamber have shown the practicability of a system of automatic venting for certain types of vapor, as well as for dust explosions.

FIGHTING A LOG PILE FIRE WITH ORDINARY FIRE HOSE

Explosions in Japan baking ovens cause great damage and have been subject to much study. After being dipped and air dried, metal parts are placed in these ovens for final baking, and the vapors given off are explosive if mixed with certain proportions of air. It is important to eliminate sources of ignition within ovens but this alone is not sufficient because experience has shown that, under ideal conditions, an explosive mixture can be set off spontaneously by the normal surface heat of the heater ribbons or gas burner boxes. This leads to the fundamental principle that sufficient ventilation must be provided to keep the amount of vapors in the oven below the lower explosive limit at all times. To assist in keeping constant check on the concentration of vapors, N. J. Thompson, of the Factory Mutual Laboratories, developed the Flammable Vapor Indicator, an original device which is of great help in studying oven conditions and arranging automatic safeguards.

AVOIDING CONCENTRATIONS OF POISONOUS GASES

Under occupancy also comes the handling of hazardous materials, of which celluloid or pyroxylin plastic is a good example. This material is unusual in that, when heated, it starts to decompose before it ignites. The gases of decomposition are inflammable, explosive, and very poisonous, consisting largely of carbon monoxide and the oxides of nitrogen. This decomposition, which can be started simply by heating to as low a tem-

PRACTICABILITY OF AUTOMATIC VENTING
Vapor Explosion in Test Chamber

perature as about 300 deg. fahr., gives off heat which further accelerates the process and raises the temperature so much that, under certain conditions, the material may ignite spontaneously, and burn with great rapidity. The gases of burning, however, are not poisonous since they are the ordinary products of combustion and consist largely of carbon dioxide and water vapor.

The gases of decomposition are given off so rapidly that, in a closed container, a pressure is quickly built up. As a test, 5 lb. of celluloid scrap were placed in a wooden box with a 3-in. hole in the top and gently heated. The gases of decomposition and decomposing bits of celluloid were thrown out of this hole with explosive violence.

Such a test suggests graphically what occurred at the Cleveland Clinic where, instead of 5 lb., nearly six tons of nitrocellulose X-ray film were stored in an old coal room in the basement. Decomposition started presumably from an electric light bulb and the gases given off with great rapidity were forced through a pipe tunnel and then up through ducts into practically every room in the clinic, trapping most of the people in the building and causing the loss of 125 lives.

Experience and large-scale tests have shown that such dangerous material should not be stored in large quantities in hospitals, but should be located in outside structures well away from the main buildings, or in vaults on the roof. Those vaults should be vented so that the gases of a possible decomposition will be safely released outdoors, and the vaults also should be sprinklered, because the water from sprinklers cools and slows down the decomposition and also washes out most of the explosive gases.

EXPLOSIVE DECOMPOSITION OF CELLULOID AT MODERATE TEMPERATURE

Finally, let us consider the benefits derived from a hundred years' application of the science of fire protection engineering. To the individual manufacturer it has provided insurance at a very low cost, as shown by the cost curve, Fig. 2, which traces principally the effect

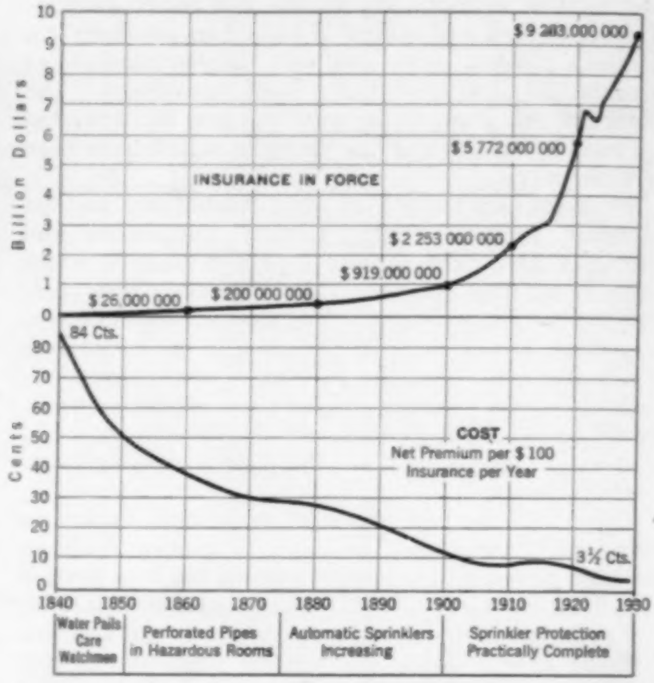
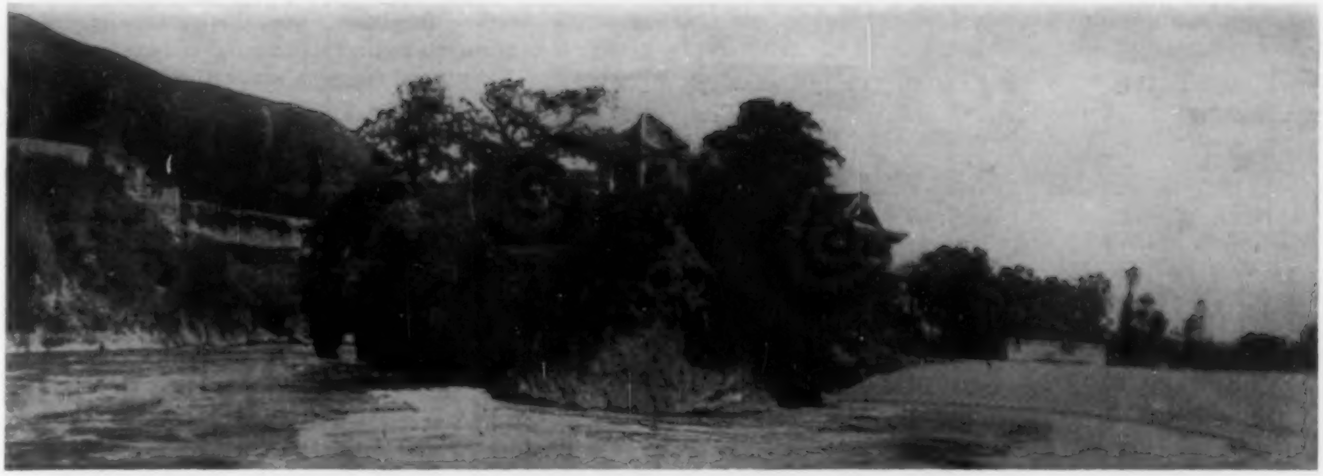


FIG. 2. COST AND AMOUNT OF INDUSTRIAL INSURANCE, 1835 TO 1930
The Factory Mutual System

of protection on the loss ratio. More important, however, it safeguards his business against interruption by fire, and the average successful business man is far more interested in seeing his business continue without interruption than in any possible saving in insurance.

Then there have been broad economic benefits to the country at large. Joining insurance with fire protection has, in the first place, resulted in one of the most successful enterprises for eliminating waste. Secondly, it has safeguarded industrial progress and development. The early plants were small, isolated, and represented relatively small values. Today, large industrial plants represent millions of dollars in buildings, equipment, and stock, and such concentrations of value would not have been safe, and therefore would not have been possible without the results achieved by fire protection engineering. We can look into the future with confidence that fire protection engineering will continue to safeguard the further growth and progress of American industry.



INTAKE AND SPILLWAY OF THE MIN RIVER IRRIGATION SYSTEM

Great Min River Irrigation Project

The Chinese as Irrigation and Bridge Engineers

By E. W. LANE

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RESEARCH ENGINEER, U.S. BUREAU OF RECLAMATION, DENVER, COLO.

IRRIGATION in China has developed vast areas of unproductive land and furnishes a livelihood for millions of people. Of the various irrigation projects, the Min River system, begun about 200 B.C., is the most ancient and most important. The ingenuity displayed by the Chinese in bridge construction is, in view of their apparent ignorance of natural laws, remarkable. In discussing the mental capacity and technical knowledge of Chinese engineers, the author shows the sympathy and understanding which result from personal contact with other peoples. This is the last of a series of three articles by Mr. Lane on Chinese engineering methods to appear in CIVIL ENGINEERING.

ONE of the three great examples of Chinese engineering, the Min River irrigation project, mentioned in my first article in CIVIL ENGINEERING, is little known because of its location in the remote Szechwan Province. It was originated about 200 B.C. by Li Ping, and is still in use today—probably little changed from its original form. Because of this system, about 950,000 acres of what would otherwise be a barren country are turned into a garden spot and thousands of people are supported by the produce raised there.

The water supply is derived from the Min River and is taken off at the town of Kwan Hsien, where the river leaves the plateau of Tibet. The Min River has a drainage area above the intake of about 7,900 square miles, on which there is an abundant rainfall, the discharge during flood seasons reaching at times more than 100,000 sec-ft. Leading from the intake is a vast network of canals branching out over the plain to carry water to the rice fields. This intake, with the maintenance work which has kept the system in operation for more than 20 centuries, is the most interesting feature of the project. A Chinese map, showing the location of the intake, is reproduced in Fig. 1.

AN INTERESTING MAP

It may be worth while to diverge from the main subject a moment to mention this example of Chinese cartography. Although Chinese maps are not as precise as ours, they are based on the same principles. The Chinese have not discovered the contour system, a recent development in our art, but their representation of the position of mountains is interesting and near the west side of the city it very nearly approaches a system of contours. The area enclosed in the heavy line is the town of Kwan Hsien, the line representing the city wall.

As the river comes down from the mountains it is first divided into two streams by an artificial embankment of gravel and cobblestones faced by rock-filled "sausages." At this point it is spanned by the suspension bridge with bamboo cables, described later. The stream to the west, which is called the Outer River, leads eventually to the Yangtze; it is navigable for small boats the year round except during the repairs which are annually made at the headworks of the irrigation system.

The other stream, known as the Inner River, leads down past the western corner of Kwan Hsien, where the intake for the irrigation system is located. The intake is a deep, narrow, artificial cut through the solid rock at a point of the hill which extends into the plain. There are no control works, but the narrow section of the gorge limits the flow entering the system to a safe quantity. This cut, through the ridge of the hill, leaves a detached knoll of rock on the opposite side of the stream from Kwan Hsien. On this knoll is situated a temple in which an image of Li Ping occupies the place of honor.

At high water, the flow of the Inner River, which

impinges directly on the knoll, is in part deflected into a great eddy on the opposite side of the river from the intake. From here it flows over a circular spillway into a channel leading back into the Outer River. A photograph shows the knoll surmounted by the temple, the narrow intake gorge on the left, and the spillway on the right. A short distance below the intake, a small breach leading from the Inner River passes through the city of Kwan Hsien, and a little farther down, the main stream divides into three parts, which spread and branch out into hundreds of waterways, taking water to great numbers of Chinese farmers.

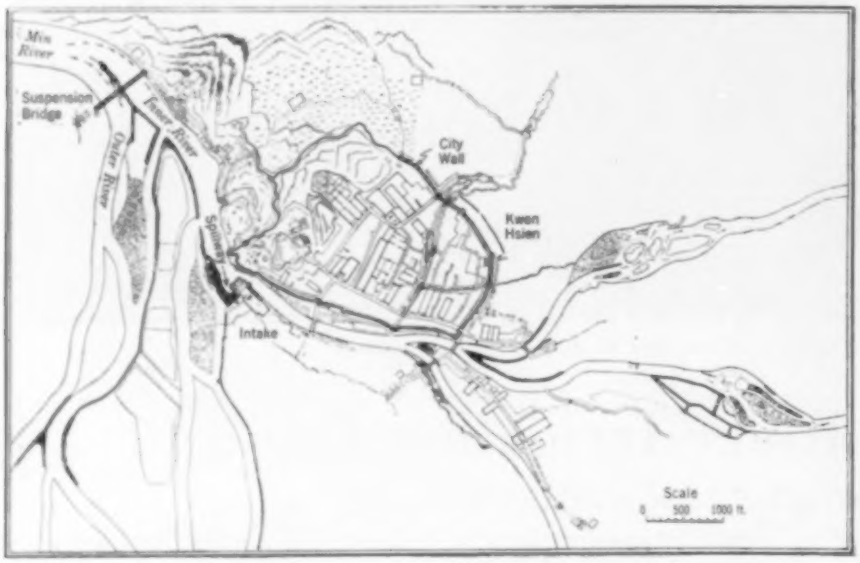


FIG. 1. HEADWORKS OF THE MIN RIVER IRRIGATION SYSTEM

Construction features of the spillway are very interesting. It consists of gravel and cobblestones covered with a layer of rock sausages, and the layout of the spillway and the arrangement of the sausages are shown in the accompanying photographs. These sausages consist of long tubular baskets of bamboo strips woven with a large mesh and filled with cobblestones. The stones are inserted through the holes, which are then made smaller by twisting or stretching the basket.

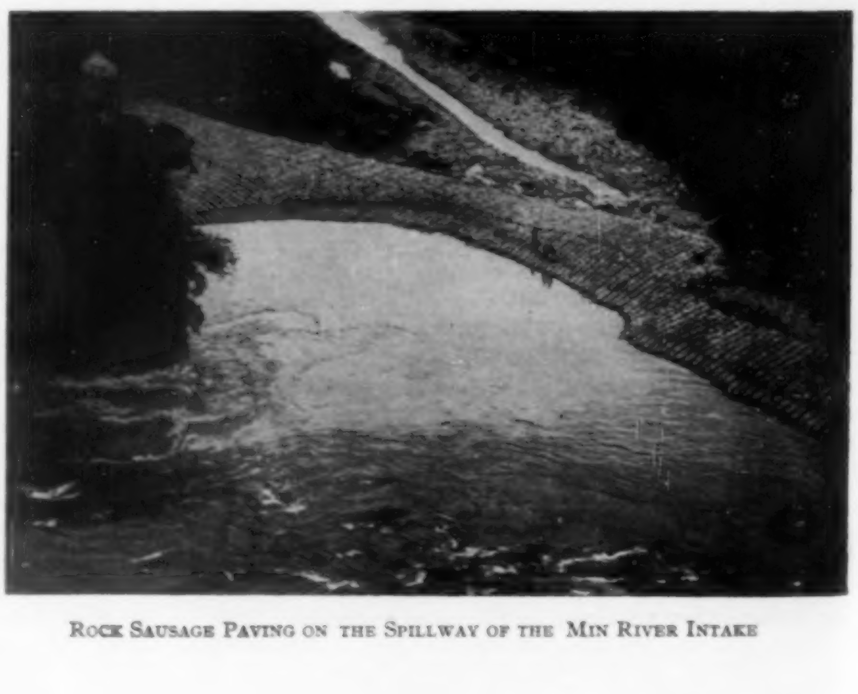
It is necessary to renew these baskets—several thousand in number—every year, but as the cost is probably not more than 25 cents each, it does not involve great expense. Rock sausages similar to these have come into use in America only during the last decade or two, so, for the benefit of those who tend to overrate the ingenuity of American engineers, it may be mentioned that this device has been in use in the Min River irrigation system longer than America has been settled by the white race.

AN ENDURING WORK

I have previously mentioned the lack of provision for maintenance of engineering works in China, but this great irrigation system is exceptional in that it is consistently maintained. Except for the annual repairs made through the past two thousand years, this great public work must long since have fallen into decay. Maintenance work is carried on during the winter when the high flows are very infrequent. About the first of December, a cofferdam is built across the Outer River and the entire flow is diverted into the irrigation system. The gravel and sand that have accumulated in the upper half mile of the Outer River are removed and the revetments of basketwork renewed. The cofferdam is then removed and rebuilt across the Inner River, which is in turn cleaned out and the sausages on the banks and spillway are replaced. On the bed of the Inner River, just opposite the spillway, lie two iron bars each of which weighs about two tons. These fix the depth to which the bed must be excavated. Each year they are covered with 6 to 8 ft. of silt, and each year the bottom is excavated until they are again uncovered. One of these bars dates back to the year 1576, but the other replaces an earlier one that was lost probably about 1865.

INGENUITY IN BUILDING COFFERDAMS

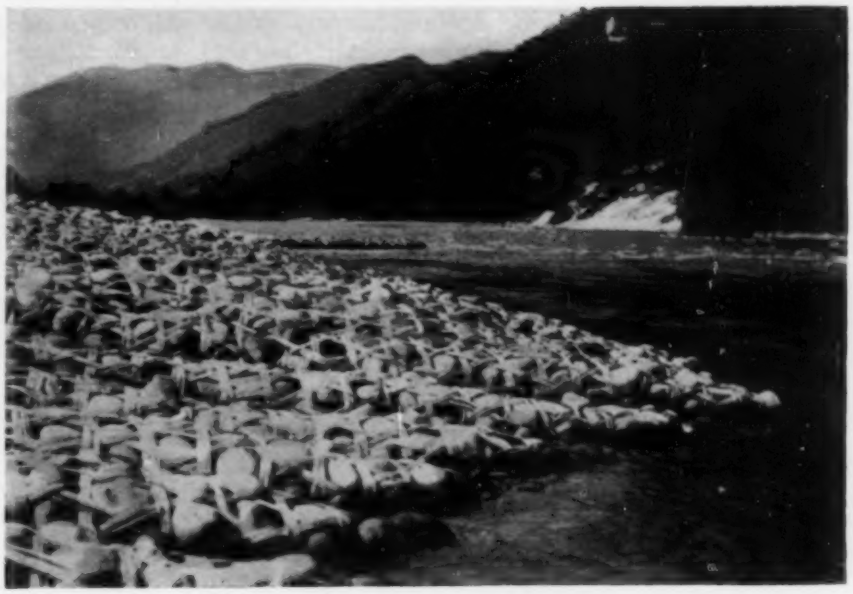
Great ingenuity has also been shown by the Chinese in the construction of the cofferdams used to close off the river, which consist of a line of rough tripods. At the bottom of each tripod, between the legs, is a bamboo basket filled with cobblestones to which the legs are attached to hold the tripod in an upright position. Pole wales are then placed between the tripods on the upstream side and covered with two layers of bamboo matting, between which earth is closely packed to hold



ROCK SAUSAGE PAVING ON THE SPILLWAY OF THE MIN RIVER INTAKE

out the water. The tripods are placed from a boat, and the earth fill is carried in baskets along a plank runway supported by the tripods.

It will thus be seen that a great deal of labor and many materials are used each year in maintenance but, because of the low cost of both labor and materials in China, the annual expense is only about $10,000. This great irrigation system is probably China's most beneficial public work. The Great Wall has long since outlived its usefulness and the Grand Canal has fallen into disrepair, but the Min River irrigation project is still bringing a livelihood to millions of people as efficiently as it did when it was first constructed over two thousand years ago.



Closer View of the Rock Sausages

THE CHINESE AS BRIDGE BUILDERS

Although the ancient Chinese made considerable progress along the line of mechanical engineering, their greatest attainments were in the field of civil engineering. On account of the extensive system of waterways, bridge engineering has been highly developed. So far as is known, the truss principle did not evolve, but this is a recent development in our engineering also. The cantilever principle is rarely, if ever used, but the beam and arch types are common and suspension bridges have also been built.

A Pile Bridge

One of the most common forms of bridges is that composed of stone slabs. One such bridge, at the city gate of Nantungchow, makes use of granite beams about 2 ft. wide and 15 in. thick, with a span of over 20 ft. This bridge is many years old and has recently been used by heavy passenger automobiles. The pile trestle is another common form; the accompanying photograph shows one about 1,000 ft. long. I wondered what the purpose of the stone piers was, since they carried only the load to the center of the adjacent pile bents. However, when I recommended that, in order to save the expense of repairing them, pile bents be substituted, I found that, in the popular view, these piers so greatly strengthened the bridge that it would be unsafe without them.

Most typical of Chinese bridges is the arch, which is usually semicircular in form. The arch ring is generally of equal thickness throughout and composed of stones accurately cut to the desired shape, as shown in the photograph. Alternate courses of headers and stretchers are used. Frequently there are beams extending through from one spandrel wall to the other, to help resist the pressure of the fill. These bridges are often beautiful structures, the Five-Arch Bridge at Yangchow having few rivals in any country.

BAMBOO CABLES IN KWAN HSIEN BRIDGE

Perhaps the largest suspension bridge in China is that across the Min River at Kwan Hsien, Szechwan, illustrated at the bottom of the following page. The cables of this bridge, which has a total length of 900 ft. and a width of 10 ft., are composed of large ropes of twisted bamboo withes or strips. There are seven spans; one of the piers is masonry, and the others are pile bents. Twenty cables are used, five on each side and ten beneath the floor, those along the side assisting in the support of the floor through wooden links. Twice a year new cables are put along the sides, those from the sides being used to replace those on the bottom, which are discarded. There is no sway bracing, and the bridge swings so much that it is difficult to get animals to cross.

Farther up the Min River there is a four-span suspension bridge, about 300 ft. long, with cables composed of iron links about 20 ft. long and 1 in. in diameter. The floor rests directly on the cables, and piers and abutments are built of solid masonry. This bridge does not

sway as does the one suspended on bamboo cables and, as the cables are practically permanent, it has the additional advantage of a much lower maintenance cost.

A TYPICAL ARCH BRIDGE
Artistic Treatment of a Utilitarian Structure

THE FIVE-ARCH BRIDGE AT YANGCHOW
A Beautiful Example of Bridge Architecture

WHITE RACE NOT SUPERIOR

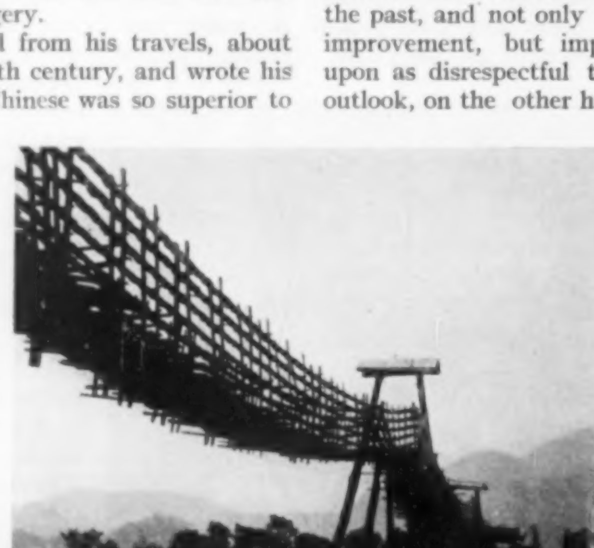
I hope that I have shown enough to make the reader share the high respect in which I hold the ability of the ancient Chinese engineers. That the stupendous progress of our profession in the past three or four centuries has put us ahead of them cannot be denied, but it must not be forgotten that some of their remarkable feats were accomplished long before most of our ancestors started to emerge from savagery.

When Marco Polo returned from his travels, about the beginning of the fourteenth century, and wrote his book, the civilization of the Chinese was so superior to that of Europe that his account was regarded as highly imaginative, but we now know that it was reasonably accurate. Our greater progress in recent years is not the result of superior intelligence but rather of a marked difference in viewpoint, for the once widespread belief that the Chinese are intellectually inferior to the white race, in general, is not well founded.

CHINESE AND AMERICAN STUDENTS COMPARED

On the other hand, some in this country have gone to the other extreme, being misled by the high grade of intelligence of the Chinese students in our colleges. They fail to realize that most of these students are the product of an intense process of elimination resulting from the inadequacy of educational facilities in China, which decrees that only the highly gifted are to have the privilege of advanced schooling. All other students are rigorously excluded by a series of examinations.

For three years I was the only foreigner in a large Chinese organization and, therefore, had exceptional opportunity to judge the Chinese. I have dealt with industrial leaders and officials, worked with Chinese engineers, and supervised the work of artisans and laborers, and it seems to me, as a result of these observations, that neither race can claim intellectual superiority. As I have emphasized before, present differences in racial development are largely due to inherent differences in outlook. For centuries the Chinese have looked toward the past, and not only has there been no incentive to improvement, but improvements have been frowned upon as disrespectful to parents and ancestors. Our outlook, on the other hand, has been toward the future, and improvements have been encouraged.



THE KWAN HSIEN SUSPENSION BRIDGE
Cables Formed of Twisted Bamboo Strips

Today, however, the point of view of China is rapidly changing and great progress will undoubtedly result. The opportunity now open to Chinese engineers to apply the science and practice of modern engineering as developed in the West to a practically virgin field is an enviable one.

ACKNOWLEDGMENTS

I wish to acknowledge indebtedness to others for some of my illustrations: to Max Wegenstein for a number of photographs of the Min River irrigation project; and to James Hutson's book, *Mythical and Practical in Szechwan*, for the map of the intake of the Min River irrigation project. I am also indebted to Mr. Hutson's book and to translations by H. K. Li for information on the Min River project.

Mississippi River—A National Flood Problem

Five Most Widely Approved Methods of Control in Outline

By J. F. Coleman
Past-President, American Society of Civil Engineers
Consulting Engineer, New Orleans, La.

IT HAS been calculated that the amount of silt annually carried by the Mississippi River is equivalent to a cubic mile in volume, and that its flow in flood would fill Lake Erie in two weeks. With the constantly increasing concentration of people living behind its levees and the rising value of property along its banks, the control of its waters is, indeed, a national problem. In the following paper, read before the Society for the Promotion of Engineering Education at Yale University, July 15, Mr. Coleman gives briefly the problem and the solutions which have been generally advanced. For the busy reader it affords an interesting insight into the difficulties involved.

THE Missisippi River, which the Indians called the "Father of Waters" is indeed a mighty stream. It is said to have 250 tributaries, of which 50 are navigable. I have never counted them, but I can well believe that these figures are not far from right (Fig. 1).

Geologists tell us that what is now the Mississippi River Valley was in an earlier age an estuary of the Gulf of Mexico extending up into the continent above Cairo, Ill., and that, in the ages which have passed, this estuary has been filled by the washings from various streams from the north, the east, and the west.

In 1544, when De Soto first gazed upon the Mississippi River at a point not far from Memphis, Tenn., it was in freshet, and he had something to say of its magnitude. Of course, the kind of information conveyed by his writings is not very informative as to high water marks and volume of flow; and, of course, no data are available as to rainfall and run-off. We do know, however, that the river was out of its banks and flooded all of the low-lying lands on each side. This was before the days of the white man in that valley, and there were no levees to restrain or attempt to restrain its floods.

For nearly two hundred years after De Soto first saw this great river, no serious effort was made by man either to curb its floods or to improve its navigability, and it remained very much as nature had made it. We have no tangible records of its floods during that period, and we do not know very much more about the problems of the Mississippi River in the early part of the eighteenth century when New Orleans was founded than we know of it in De Soto's time.

THE FIRST LEVEES

With the founding of New Orleans, however, the construction of levees was begun. The city was at first virtually surrounded by a low levee which was sufficient to exclude the high waters of that time. With this beginning, the levees were extended up and down the river on both sides until, ultimately, very nearly all of the low lands on both sides of the river were, after a fashion, protected. These levees were originally, for the most part, built by the property owners on locations of their own selection and to such grade and section as they elected. This led to a great variety of standards for grade and section, as a result of which breaks in the levee system were plentiful at every freshet.

In 1850, Congress passed an act directing "a topographical and hydrographical survey of the delta of the Mississippi River with such investigations as may lead to determine the most practicable plan for securing it from inundation." The results of this survey were published in the report of Humphreys and Abbott on "The Physics and Hydraulics of the Mississippi River."

In 1879, the act creating the Mississippi River Commission was passed; and in the meantime, legislation was secured in several of the states creating levee districts and boards of levee commissioners with certain taxing powers. So a standardization of the levees as to grade and section was begun. The increasing dimensions of the levees are graphically portrayed in Fig. 2.

Fig. 1. The Drainage Area of the Mississippi River

WORK OF THE COMMISSION

The Mississippi River Commission, in time, began to take a hand here and there in the construction of levees on the theory that such construction at the selected points was an aid to navigation. The amount of participation by the Federal Government gradually increased as the years went by. The Mississippi River Commission also undertook the revetment of caving banks at various points, and as a result of its studies recommended certain tentative grades and sections for the levee system.

In the course of the years, much more was done in bringing the levees to these standards, but the work had not been quite completed when the flood of 1927 came with its disasters, challenging the attention of the Nation and ultimately resulting in Congressional action which it was hoped would safeguard against a recurrence of such troubles. The progress of the failure of the levee at McCrea, La., is shown in Fig. 3.

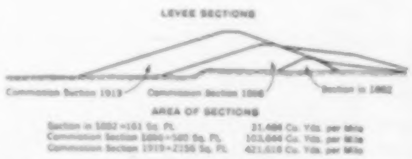


FIG. 2. THE "GROWTH" OF THE LEVEES

As an aid to understanding the situation, Fig. 4 shows a map of the Mississippi River from Cairo to the Gulf. This and the other illustrations used are from the files of the Chief of Engineers, U.S. Army. The river's low water discharges are approximately as follows:

Columbus, Ky. (20 miles below Cairo)	Gage 2.3	71,000 sec-ft.
Vicksburg, Miss.	Gage 4.7	97,000 sec-ft.
New Orleans, La.	Gage 0.15	135,000 sec-ft.

High water discharge is approximately as follows:

Columbus, Ky.	Gage 55.7	2,015,000 sec-ft.
Vicksburg, Miss.	Gage 58.40	1,826,000 sec-ft.
New Orleans, La.	Gage 21.27	1,358,000 sec-ft.

The maximum recorded discharges of the tributaries are as follows:

Upper Mississippi	450,000 sec-ft.
Missouri	900,000 sec-ft.
Ohio	1,400,000 sec-ft.
Arkansas	814,000 sec-ft.
White	400,000 sec-ft.
Red	220,000 sec-ft.
Total	4,184,000 sec-ft.

In addition to this must be considered the discharges of the St. Francis, the Yazoo, the Tensas, and the Ouachita.

The flood problem of the Mississippi River consists, first, in determining what proportion of this discharge volume more than 4,000,000 sec-ft., must be provided for and, second, in providing for it. In the so-called Jadwin Plan, it was proposed to provide for a total discharge of 3,000,000 sec-ft. at the latitudes of Old River; and in the plan submitted by the Mississippi River Commission, it was proposed to accommodate 2,850,000 sec-ft. at the same latitude. It would appear that both of these plans assumed that there was no reasonable probability of all of the tributaries being in freshet in synchronism.

INCREASED VOLUME MUST BE PRESERVED

As the maximum recorded discharge into the Gulf of Mexico has been 1,358,000 sec-ft. for the Mississippi River, and 750,000 sec-ft. for the Atchafalaya, it will be seen that on a basis of the Jadwin Plan the discharge of these two streams will have to be increased some 900,000 sec-ft., which is not much short of 50 per cent.

It would not be an easy or a simple matter to make provision for any such additional volume of water anywhere, and in the case before us there are other factors which render the problem even more complex. A great number of solutions have been advocated, many of which are exceedingly ludicrous, but those which have been most consistently advanced through the years are:

1. Confinement aided by bank revetment to protect against erosion
2. Outlets or spillways to relieve the stream of its surplus waters
3. Detention reservoirs to withhold surplus water
4. Reforestation of cut-over lands
5. Improvement of channel

At the meeting of the American Society of Civil Engineers held in October 1927, at Columbus, Ohio, many papers were delivered on various phases of the Mississippi River flood problem. There was considerable discussion of these papers at that meeting, and there has been written discussion since. All of this material has been embodied in the TRANSACTIONS of the Society, 1929, page 655, and any student of the problem would gain much from a reading of these papers.

THE CONFINEMENT PLAN

In every proposed plan, levees are to be used, as no plan anticipates carrying the water within banks without overflowing them. The confinement plan, however, is sometimes misnamed the "levees only" plan. It is based upon the theory that, if confined, the river will scour for itself a channel of sufficient dimensions to carry the burden. It involves protection of the banks from the erosive action of the current where necessary, and does not preclude the diversion of waters before entering the river. Neither does it preclude the improvement of the channel by cut-offs or by other means. It is a well recognized principle of hydraulics that a stream of large sectional area will have a greater velocity at a given slope than will one of small sectional area, and that therefore a given body of water will flow from one given point to another more rapidly in one stream than in two or more.

The so-called Lower Mississippi River (from Cairo to the Gulf) has an average slope of not far from 3 in. per mile in freshet. This slope, however, is far from uniform, and a profile of the river surface would be a line broken into relatively short stretches showing from as much as 6 in. per mile to so little as to be almost negligible. In cross section, the river is also quite variable, both as to area and as to shape. Still further variations result from the location of the levees on each side, which in some cases are near to the bank of the river and in others are a mile or more from it. Velocities in such a stream are as variable as one would expect them to be, so the stream is by no means a highly efficient conduit for the waters it

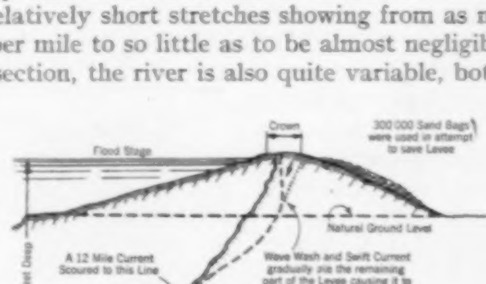


FIG. 3. LEVEE AT MCCREA, LA., FAILING DESPITE EFFORTS TO SAVE IT DURING 1927 FLOOD

carries. There are unquestioned possibilities for improving its carrying capacity without exceeding those velocities which already exist in its most efficient reaches, but this would involve some straightening of the river in places by cut-offs and by other means.

To do this intelligently without danger would require studies of critical velocities, of slopes to produce such velocities as may safely be sustained. With a surer knowledge than we how have, it would doubtless be possible to bring about a greater uniformity in slope, section, and velocity than now exists, and to materially improve the efficiency of the channel.

There has heretofore been an aversion on the part of the authorities to anything in the nature of cut-offs, because of their probable disturbance of the regimen of the stream.

RIVER HAS BEEN LENGTHENED

For lack of means with which to protect caving banks, the bends in many instances have lengthened themselves, until now the river from Cairo to the Gulf is perhaps as much as 75 miles longer than it was in 1882. In fact, in the short reach from Arkansas City to Greenville, which includes the so-called Greenville Bends, the river is now eight miles longer than it was in 1882. This lengthening of the stream brings about a change of regimen which, while more gradual than such a change produced by a cut-off, is nevertheless quite as objectionable in many ways.

Hydraulic Methods Used in Enlargement of Levees in Northern District

It seems to have been generally believed that, as Nature abhors straight lines, the more crooked and tortuous the stream, the nearer it approaches to the ideal. I feel that this view is in error and that we might to advantage do a great deal of straightening to the river.

It is a fact that on Red River above Shreveport, where the Government has had no money to prevent cut-offs, there is a long reach which formerly had many sharp bends and where the river has straightened itself by means of cut-offs. There the channel has been stabilized, the low water elevation is lower as is also the high water elevation, and the navigable depth of water at low water is greater. In other words, the navigation is improved and the flood hazard reduced.

Crevasse in Bayou de Glaise Levee Near Bordelonville, La., May, 1927, and Resulting Damage to Adjacent Town

Nature has indicated its own tendency to these cut-offs over the whole length of the Mississippi River, and I think it likely that we will improve matters by assisting nature in this respect rather than by interfering with it.

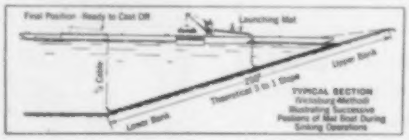


Diagram of Sinking Mats

If we need to shorten still farther the route to the sea, we could permit or aid the river to go by way of the Atchafalaya instead of by way of the present channel of the Mississippi River, which would shorten the distance by about 150 miles.

If, notwithstanding the improvement of channel previously suggested, it is felt that there is more water than the Mississippi River can safely handle, it would be possible to divert the waters of the Arkansas and, if necessary, of the White and the St. Francis down the channel known as the Boeuff River and thence into the Tensas, Red, and Atchafalaya to the sea without ever permitting them to reach the Mississippi River.

OUTLETS AND SPILLWAYS

Ever since I can remember, there have been proponents of outlets, but the spillway as a solution of the flood troubles is somewhat newer. There were originally a number of outlets, as, for instance, Cypress Creek Gap, just below Arkansas City, Old River, Bayou Plaquemines, Bayou-Lafourche, and others less well known. Below each of these there was a bar in the river and, as each of them was closed, the bar disappeared. The only one now remaining is that at Old River. Here, to my personal knowledge, the Mississippi River in 1890 had a low-water depth in channel of 30 ft. Now dredging is required at every low-water season to provide 8 or 9 ft. The official surveys of the Mississippi River Commission show a loss in low-water cross section at this point of 65 per cent, and there is no way in which to account for this reduction excepting the presence of the outlet.

In the course of the years, there have been many crevasses or breaks in the levee system during high water, and some remained open for considerable periods of time —for example, Morganza for 12 years, and Bonnet Carré for 8 years. Thus, these crevasses became spillways and operated as such until they were closed.

Morganza was on the west side of the river in a long bend on the concave side. The river was wide and deep in this bend—so wide and so deep that there was ample room for several steamboats abreast going upstream to pass several other steamboats abreast coming downstream at low water. Before the crevasse had finally been closed, we are informed that the channel was so depleted that it was reduced to a narrow "gut" in which two steamboats could not pass each other.

At Bonnet Carré, there was also a very considerable

reduction in cross sectional area of the river just below the crevasse, though not to any such extent as at Morganza. When these crevasses were closed, the river immediately reestablished its former section, within one or two high-water seasons. It is unfortunate that actual surveys and soundings are not available, to give the exact extent of the reduction in area and the term required for its reestablishment.

PLACING SAND BAGS ON LEVEE AT LAKE-PORT DURING 1927 FLOOD FIGHT

RESERVOIRS AND REFORESTATION

I think it would be admitted by any student of the problem that detention reservoirs alone could not be depended upon to control the floods of the Mississippi River. It is possible, however, that they might be useful as an adjunct. At this time, there are not sufficient data available to enable me to form a definite opinion as to the extent to which aid might be depended upon from this source, but I understand that surveys and studies are now in progress and I am awaiting with interest the results.

Proponents of reforestation promise great results in its name. Even assuming the correctness of their claims —which I doubt—it would take so many years to reforest all of the suggested area that the whole valley could be drowned out a number of times before these areas could be expected to render service. Perhaps reforestation would help in some degree, but I fear that it would be a very infinitesimal aid.

At any rate, it is a subject on which much has been written pro and con. We have very definite knowledge that the flood which De Soto saw in 1544, before any trees had been cut, did overflow the banks of the river, from which we may with reason deduce that as the forests did not prevent floods in the past, reforestation would not protect us from them in the future.

A SEARCH FOR THE TRUTH

We know definitely that the river, as it presently exists, will carry approximately 1,000,000 sec-ft. at a bank full stage, and we know that we must make provision for a greater amount than that—surely for another million, probably for two millions, and possibly for three millions.

Just how this is to be done is the problem, and the problem is by no means solved yet. We are lacking in basic fundamental data on which to found a sane, sound engineering plan. Some of those data are being accumulated now and, as time goes on, we shall no doubt learn more and more of the facts which we need to know.

The recently authorized hydraulic laboratory may provide answers to some of our questions, and the topographical surveys now in progress may answer others. Eventually we shall know the answers to all of them and may then press forward with assurance. In the meantime, we are groping more or less in the dark.

I entertain certain views and theories on the subject which I recognize to be no more than views and theories. Other engineers, at least as capable, entertain different views and theories. Perhaps I am right; perhaps they are right. If we had available all requisite data, we should soon know who is right—or if any of us is right—and all major differences of opinion would disappear.

As engineers, we are seekers after the truth and, when we find it, all of us can unite in work that is based upon it. In the meantime, the authorities are going forward as well as they may with a plan which no doubt is imperfect in many of its details. These imperfections or probable errors will without doubt develop themselves to be such in time and will be corrected.

While the plan under execution varies greatly from the ideas and views which I entertain, I have felt from the outset that I would not stop the work if I could—particularly in view of the extensive and elaborate investigations now being carried forward, which will develop definitely many of these moot questions.

FIG. 4. MISSISSIPPI RIVER, CAIRO TO THE GULF

Brook's Hollow Earth-Fill Dam

Prize Student Paper Describes Design and Construction Features

By Eldred D. Smith

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Local Section interest in Student Chapters takes many forms. At Philadelphia the student chapters are encouraged to further effort by the award of Junior memberships in the Society to the writers of meritorious papers submitted in competition. This paper won, in the 1930 competition, one of the prizes offered by the Philadelphia Section. On cooperative work, Mr. Smith was with the Palisades Interstate Park Commission as an inspector during a large part of the construction of the Brook's Hollow Dam.

About 40 miles up the Hudson River from New York and 8 miles inland, the Palisades Interstate Park Commission has completed the construction of an artificial lake for recreational purposes. Several thousand campers make use of the facilities of the region each season. A long, narrow valley converges to a width of 700 ft. at the dam site. A brook, which is the outlet of other natural lakes above, flows through the marsh occupying the floor of the valley.

In the profile, Fig. 1, is shown the quality of the material along the center line of the dam. The material forming the hillsides consists of gravel, boulders, and clay, and the marsh is made up of about 10 ft. of soft marsh deposit and boulders, below which are several strata of water-bearing sand and blue clay. The bedrock is a very hard, smooth-surface granite.

At the west end of the dam site, about 200 ft. up the slope of the hill, was what appeared to be an outcropping of bedrock, and it was believed that this bedrock rose from the level shown by the test borings to that of the outcropping. This supposition was later shown to be erroneous.

DIFFICULTIES ENCOUNTERED

Before the design of the dam was begun, test borings were made at the proposed site. A great deal of difficulty was experienced in making these, on account of the large boulders encountered in drilling. Several holes were lost and only four gave consistent results, indicating that bedrock was about 30 ft. below the level of the marsh. With this information at hand, it was found that an earth-fill dam with a concrete core wall would be the most economical owing to the great depth to bedrock as compared with the height of the flow line. So it was decided to build a gravity section spillway at the highest elevation of bedrock to take care of the overflow. The location of a road crossing the marsh necessitated running it across the top of the dam and spillway. The design of the cross section of the earth fill for the main part of the dam is shown in Fig. 2.

The general design of the spillway and bridge, shown in the illustration, consisted of a gravity section 40 ft. long over which the reinforced concrete bridge was constructed. The bridge floor slab was made up of a 6-in. slab supported by longitudinal I-beams, spaced 4 ft. on centers. In the design of the transverse arches, the arch action was neglected because the column supports could not resist a thrust without high bending stresses. Arches show along the face of the spillway, but here again the arch action was not considered as the load was carried by a channel over which the reinforcing rods of the floor slab were bent.

Provision for draining the lake was made by a concrete box culvert sluiceway located at the lowest elevation of natural ground extending through the earth fill and core wall. The sluice gate was mounted on a solid concrete tower at the upper end of the sluiceway, Fig. 2.

THE MAIN PROBLEM

Although the job as a whole would not be considered very large from the standpoint of quantity of material involved, the difficulties encountered made it very long and expensive. The main problem was, of course, the construction of the concrete core wall, which was about 600 ft. long and 67 ft. high at its maximum section, 32 ft. below the marsh level and 35 ft. above it. The material through which the core-wall trench was excavated contained water under pressure, many large boulders, and considerable quicksand. Owing to the presence of the boulders, it was impossible to use well points for drying up the site, or to drive sheet piling in advance of the excavation, so the only method remaining was the open-sheeted trench.

Where the ground level was above that of the marsh, a steam shovel was used to strip off the layer of clay and gravel down to the layer of boulders which were on the surface of the bedrock. A temporary 8-ft. by 3-ft. wooden flume, 200 ft. long, built where the brook crossed the dam location, kept the water from running into the core-wall excavation. The flow through the flume varied from a very small stream of about 3 sec-ft. to 25 sec-ft. after heavy rains.

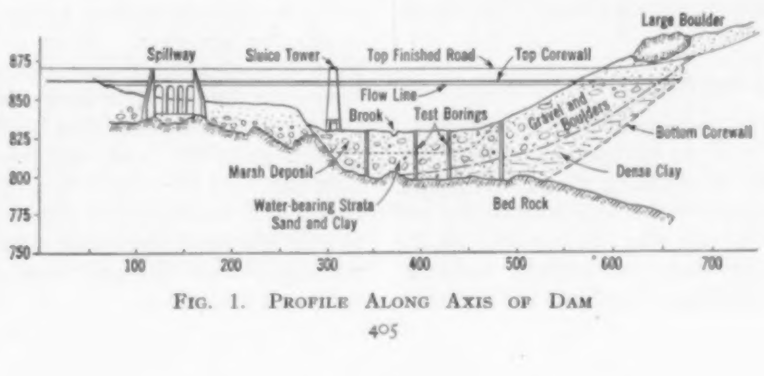

Fig. 1. Profile Along Axis of Dam

CORE-WALL EXCAVATION

Work on the core-wall excavation was started in the fall of 1927 by filling along the upstream side of the line of the trench to increase the stability of the ground. A truck crane with a clamshell bucket was brought in, and a trench 12 ft. wide and 6 ft. deep was excavated, the maximum depth that could be dug in the marsh without the sheeting in place. Rectangular wooden bracing was then placed in the trench, and the sheet piling started.

For the sake of economy in equipment and material, the core-wall excavation was carried on in 60-ft. sections, each section being finished and the core wall poured before the next was started. With this arrangement, all the material for one section could be handled by a stiff-leg derrick with one set-up.

CONSTRUCTING THE CORE WALL

The sheeting was driven down with mauls while the excavation proceeded; and the excavated material was placed in bottom dump-buckets and hoisted out of the trench by the derrick. When the first row of sheeting had been driven its full depth, a second row was started in practically the same manner.

Comparatively little difficulty was encountered in putting in the first row of sheeting and bracing, but when the second row had been put in various difficulties were encountered. The level of the bottom of the trench was now below the level of the marsh deposit, and the water-bearing strata of sand and clay were reached. The water courses through the sand were under pressure and continually boiled up through the bottom of the trench. Sometimes, when a new course was struck, the water would spurt 2 or 3 ft. into the air until the pressure relieved itself, and pumps were kept running continuously to keep the water from filling the trench. Quicksand conditions resulted, making the whole mass of the bottom of the trench like jelly.

THE LABOR PROBLEM

Considerable difficulty in keeping labor was experienced during this stage of the work as inexperienced laborers, working along in a section of cribbing, would often have to be extricated by the derrick. Another difficulty encountered in sinking the trench was the removal of the large boulders. When they were too large to hoist out by chain, or protruded only part way into the trench, a few holes were drilled in them and they were loaded with a charge of slow-firing, gelatin powder.

When the excavation had reached a depth of about 20 ft. below normal ground level, the upstream sheeting and bracing began to settle and skew as the downstream bank became dry and stable, Fig. 3. After a heavy rain, the material of the upstream bank became almost fluid and excessive strains were thrown on the bracing A few 10-in. by 10-in. rangers were snapped in two, making it clearly evident that a different system of bracing would have to be used or there would be danger of losing the entire section of trench. A new system of bracing was devised, Fig. 3, and the excavation was continued down to bedrock. On the upstream side, the bank had settled nearly 6 ft., only two rows of sheeting being required to reach bedrock, whereas on the downstream side three rows were required.

CONCRETING THE CORE WALL

The new system of bracing also greatly facilitated the pouring of the core-wall concrete. A footing covering the entire bottom of the trench was first poured. Forms were then erected between the upright bracing, and the $1{:}2^1/_2{:}5$ concrete poured up to the first cross brace between the uprights. When this had set, the uprights were braced against the concrete itself, and the cross braces removed. The concrete was then poured up to the level of the next cross brace, the process being repeated until the core wall was above the top of the sheeting. In the concreting of the core wall, all bulkheads and construction joints were made with V keys to give a water-tight bond; and at the end of each day's pouring, these V keys were placed in the wall and weighted with stone.

During a period of dry weather, when the banks were in their most stable condition, the sheeting and bracing were pulled, and it was found that about 90 per cent of the timbers could then be salvaged in a usable condition.

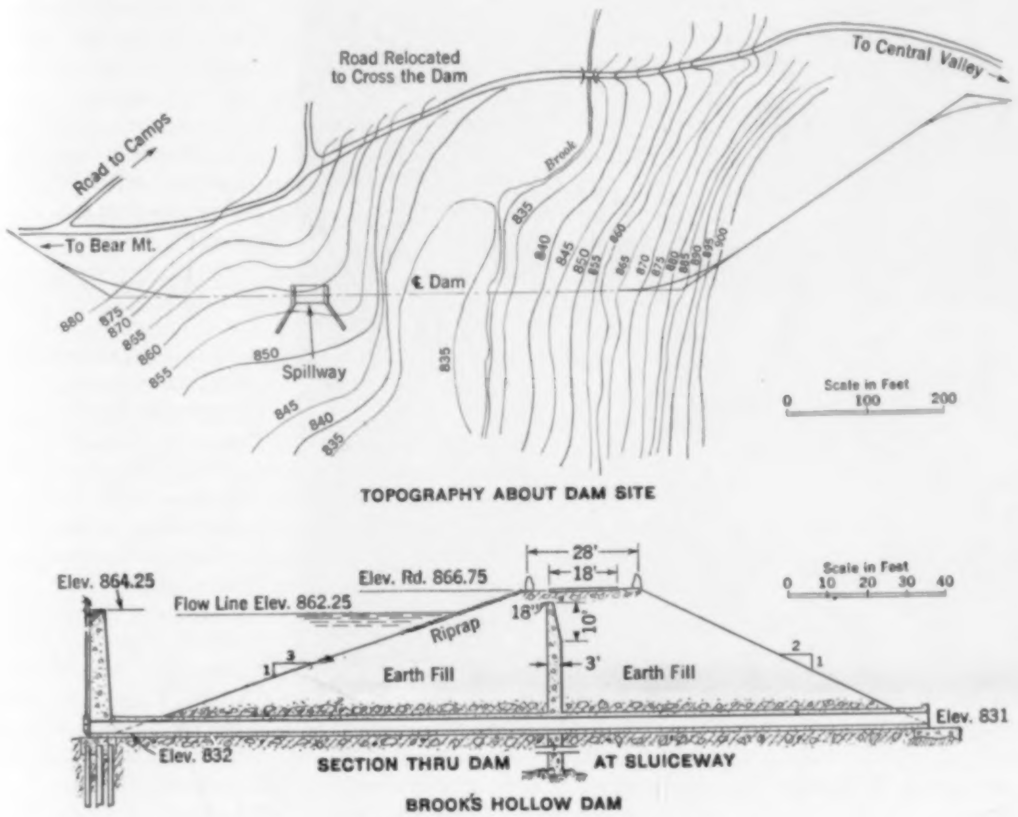

Fig. 2. Topography of the Dam Site
Cross Section Through the Dam at the Sluiceway

In constructing the sluice, the first operation was to excavate the loose dirt and mud along the center line and to fill in this ditch with rock to increase the stability of the soil. A reinforced flat slab floor was first poured, and the sides and roof were then poured in one piece. At the upstream end of the sluiceway, the concrete tower which was to carry the sluice gate was constructed on a cluster of piles to carry the weight of the tower. Then a concrete footing, 4 ft. thick, was poured around the pile cluster, and the reinforcement of the tower, which consisted of a small I-rail in each corner, was placed in the footing. This reinforcement was considered necessary in order to resist the force of ice and wave action in the lake.

FURTHER CONSTRUCTION DETAILS

Excavation for the spillway footing was partly done with the steam shovel. As the top of the rock at the spillway was badly broken and fissured, it was found necessary to excavate about 8 ft. before a satisfactory foundation was reached. Most of the rock excavated from the footing was washed and placed in the concrete of the footing. Box keys were poured as an integral part of the footing in order to insure a good bond with the gravity section.

Before pouring began, the form for the gravity section was made complete. It was divided in the middle by a bulkhead and concrete was placed alternately in one section and then in the other until pouring was finished. Large V keys were made in each end of the gravity section to give a good bond between the gravity section and the bridge abutments. The concrete proportions, which were approximately 1:2½:4, made a rather soft mix so that plums could be easily sunk in the concrete. About 25 per cent of the total volume of the concrete was made up of the plums.

DESIGN OF FORMS

Form work for the columns and arches for the spillway were designed so that all the concrete up to the level of the I-beams of the bridge floor could be poured in one piece. The height to which the concrete in the columns was poured was about 25 ft., giving an approximate pressure of 3,750 lb. per sq. ft. at the bottom of the form. The forms were made to take care of this pressure but, unfortunately, a 2-in. by 4-in. timber, badly weakened by dry rot, near the bottom of one of the columns, gave way when the concrete in the column was about 17 ft. deep, making a 6-in. bulge in the form.

With wire twisters connecting the ends of 4-in. by 6-in. timbers, placed across the form at the bulge, pressure was brought to bear against the bulge. By vibrating the forms with hammers, the concrete was forced to rise back up into the form until the bulge was practically gone. When the forms were stripped, the bulge was not noticeable.

BEDROCK DISAPPEARS UNDER CORE WALL

At the location where the slope of the hill became quite steep, it was found that the rock slope began to go down instead of up as was expected (Fig. 1), there being a large outcropping of rock of the same kind as the bedrock farther up the slope. When the depth of excavation in the hillside was about 70 ft. from the original surface of the hill, it was evident that it would not be feasible to try to run the core wall to rock. Fortunately, the material encountered in the hillside at this depth was a dense, dry clay. So it was decided to step-up the core wall into the hard clay and to make a puddle-fill along

the upstream side. Since the material at a higher elevation in the hill was porous gravel, the puddle-fill would effectively seal the bottom of the core wall,

THE GRAVITY SECTION SPILLWAY, ROADWAY, BRIDGE, AND DAM

which was continued up the slope, following the clay until it reached the flow line.

HANDLING THE MATERIAL

In making the fill, the best quality of material was placed in the fill on the upstream side and the core-wall trench was kept filled with water to puddle the fill along the core wall. The material for the fill was hauled by trucks, dumped in a pile, and spread by a bulldozer attached to a tractor. The dumping was done in such a manner that the trucks would run over each successive load. Six-ton trucks with solid tires were used, so the compaction was very thorough. The top 30 ft. of fill was faced with riprap stone, brought in by truck and placed in position by the crane. The downstream side of the fill was sodded and planted with shrubbery to prevent erosion.

AGGREGATE OBTAINED NEAR THE SITE

Owing to the isolation of the site, the aggregate for the concrete in the dam was obtained from a stone crusher and a sand-washing plant constructed near the dam. The stone that was obtained from the crusher was a hard granite. The crusher plant was near the main road, about two miles from the dam. The sand-washing plant was located about seven miles from the job. Sand obtained from this plant was sound and sharp but, as the grading varied considerably, it was necessary to vary the amount of cement used.

A high-tension transmission line from Monroe, N.Y., passed near the site of the dam so that the power for the concrete mixers, pumps, and hoists was conveniently obtained from this source. The project was completed in June 1929.

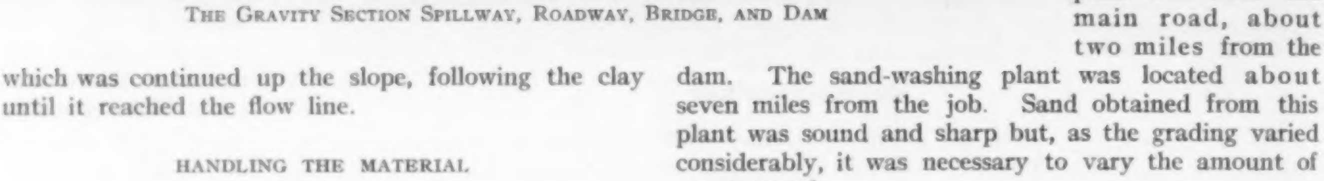

FIG. 3. CORE-WALL TRENCH BRACING

An Unusual Sea Wall Achievement

Long Beach, California, Builds a Municipal Recreation Project

By C. M. Cram

Member American Society of Civil Engineers
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How the deteriorating effects of animal life and mineral content in sea waters and the destructive action of ocean waves and tides on shore and shore construction have been provided for in building the municipal pier-auditorium project of Long Beach, Calif., are here explained. A horseshoe-shaped granite breakwater, three-quarters of a mile long, protecting a creosoted wooden-pile pleasure pier, and built on the ocean side of the breakwater, encloses a 40-acre, still-water basin for recreation purposes. Within the enclosure, a municipal auditorium building is also under construction to replace one now outgrown. This development shows an unusual application of marine construction to a civic center improvement.

Within a few weeks, the City of Long Beach will observe the completion of Rainbow Pier and its dedication to public use. This pier is a part of the comprehensive improvement program locally referred to as the "pier-auditorium project."

Engineering plans for it were prepared early in 1928 by the city engineering department. For years preceding the crystallization of the idea, damaging seas along the ocean front in the business section of the city had necessitated the use of sand bags and temporary barricades during concurrences of storms and high tides. These emergency measures failed to afford permanent protection, and the tendency of the ocean beach toward recession at the locality had not been overcome. The municipal auditorium, a frame building supported on piles in the vicinity thus affected, had not only been outgrown, but the increasing rate of deterioration demanded its early replacement. The municipal pleasure pier, for many years a landmark of the local beaches, likewise had reached a state where frequent and costly repairs were required.

It was therefore expedient and possible to include in the general scheme of development the creation of an ideal site for a new auditorium building, the replacement of outgrown and practically worn-out buildings with structures of greater permanency, the solution of the problem of ocean-front control in the business section of the city and, at the same time, provision for a civic center offering recreational advantages not available elsewhere on the Pacific Coast.

A bond issue of $2,800,000 was therefore submitted to the voters and passed May 1, 1928, to cover the expense of a pleasure pier, auditorium fill, and accessories at an estimated cost of $1,400,000, and an auditorium building at an estimated cost of $1,400,000. The first of these projects included, besides a pleasure pier, the construction of a rubble-mound breakwater connecting the foot of Pine Avenue with the foot of Linden Avenue, and enclosing about 40 acres of sheltered water area within which an eight-acre tract at the foot of American Avenue was bulkheaded and raised by hydraulic fill to an elevation suitable for the auditorium site. In connection with filling for this site, sand was deposited on the eroded beaches within the enclosure formed by the pier enrockment to raise and widen them. Fig. 1 shows the general plan of the project. Incidental to these principle items of the project was the revision of the existing storm water drainage system serving the district directly shoreward of the improvement frontage.

The substructure of the pier trestle consists of 255 seven-pile bents, 15 ft. apart, capped with 12- by 12-in. timbers, drift-bolted, and strapped to the piles. The piles are of creosoted Douglas fir, 16-lb. treatment, of lengths sufficient to provide from 20 to 25 ft. of penetration in depths varying from the ocean beach to 26 ft. at mean lower low water. The creosoted piles, driven in advance of the deposit of stone in the enrockment, were jacketed to prevent damage to the piles by abrasion.

Piles were driven by two steam skid drivers, each equipped with a drop hammer and a jet pump. The forward driver placed four of the seven piles of each bent, and the rear driver placed the three piles required to complete the bent as well as an extra pile on the landward side of the substructure to carry the contractor's track for the delivery of stone in the enrockment.

Alignment was designated by instrumentmen employed by the city. Coordinates of each bent center were calculated before construction of the substructure was undertaken. Bent centers, located by transit deflections and long-chord measurements as the work progressed, were frequently checked and rectified by triangulation from a shore base line. Although subject to the sway of the trestle in the seas, final alignment as thus designated did not at any time during the progress of the driving deviate more than a few inches from true position.

PIER TRESTLE SUPERSTRUCTURE

The pier, which is 3,800 ft. long, is decked to form a 20-ft. roadway paved with 5-in. asphaltic concrete, flanked on either side by a boardwalk 8 ft. in width. The roadway pavement was laid on a deck of 2- by 4-in. timbers laid on edge and supported on 4- by 18-in. stringers spaced to carry standard highway loadings. Sidewalks of 3-in. plank are supported on 4- by 16-in. stringers. Anchorage of decking to stringers and of stringers to caps is effected by steel straps designed to withstand the lifting force of heavy seas.

To offset the force that might result from the horizontal sweep of seas passing under the trestle, an underdeck of 4- by 8-in. timbers on 10-in. centers was placed on the shoreward half of the trestle. The roadway deck of the pier is 18 ft. above mean lower low water

along the seaward portions of the pier and falls on a 2 per cent grade toward the shore connecting with the grade of Seaside Boulevard, which is about 12 ft. above mean lower low water by easy vertical curves.

CONSTRUCTION DETAILS

Both seaward lamp standards and newel posts were set on true alignment, and the guard rails, pavement headers, and pipe railings were sprung to the curvature of the pier.

As sufficient timber decking was completed to constitute a day's run of paving equipment, the asphaltic concrete deck was laid to protect the laminated timber sub-deck from the effects of weather and the necessary construction traffic. Three such runs were made in completing the roadway pavement.

Sway braces consist of horizontal, diagonal $1^1/_4$-in. round rods that connect bands surrounding the center and seaward piles of each bent with those of the next bent. Turnbuckles on each rod were tightened progressively from the apex of the pier to both shore ends. Construction of the shoreward sidewalk, similar in design to the seaward sidewalk, was undertaken after the pier enrockment had been completed and the track used in the delivery of stone removed.

A lighting system and fire lines serving the pier were installed by the City of Long Beach. The upper handrail, composed of $2^1/_2$-in. wrought iron pipe threaded through newel and lamp posts, forms the conduit through which electrical conductors connecting lamps in series are carried. The lower railing of 2-in. iron pipe forms a portion of the water service on the pier and serves as a ground for the lighting circuits. There are 128 lamps on the pier, and seven of them are wired for operation from sunset to sunrise in compliance with the requirements of the U.S. Lighthouse Service.

A 4-in. fire and water line installed by city forces along the seaward ends of the caps of the pier trestle provides fire outlets at frequent intervals around the pier.

Construction of the pier superstructure was accomplished in a total working period of about $5^1/_2$ months. Approximately 1,470,000 board ft. of lumber were required.

PIER ENROCKMENT

The breakwater, or pier enrockment, consists of a rubble-stone mound, so placed with reference to the pier trestle as to permit waves to pass under the deck of the pier while being tripped on the seaward face of the enrockment, comprising a safeguard against the destructive effects of the seas to both enrockment and pier trestle. The details of the granite breakwater and pier are shown in Fig. 2.

Sizes of stone placed in the enrockment were so graded as to provide maximum density in the completed structure near its shore ends and maximum porosity in the higher portions of the enrockment along its seaward arc. The stone work thus placed permits free tidal flow of ocean waters into the lagoon, formed by the enrockment, on flood tides and from the lagoon into the ocean on ebb tides. Increased density of the structure near its shore ends prevents the sands of littoral currents from passage through the enrockment. Stone used on the seaward face was so graded as to expose large blocks to the direct impact of the seas.

PURPOSE OF THE ENROCKMENT

The enrockment serves to still the waters of the area enclosed by it, thus making it suitable for bathing and aquatic sports. At the same time, it protects the bulkhead retaining the reclaimed area comprising the auditorium site and grounds. Removal of the protective works from the immediate vicinity of the auditorium building, not only insures the eight-acre reclamation against the destructive effect of the seas, but it also removes the noise of pounding waves from the auditorium building.

From the standpoint of design, the enrockment serves to steady the pier struc-

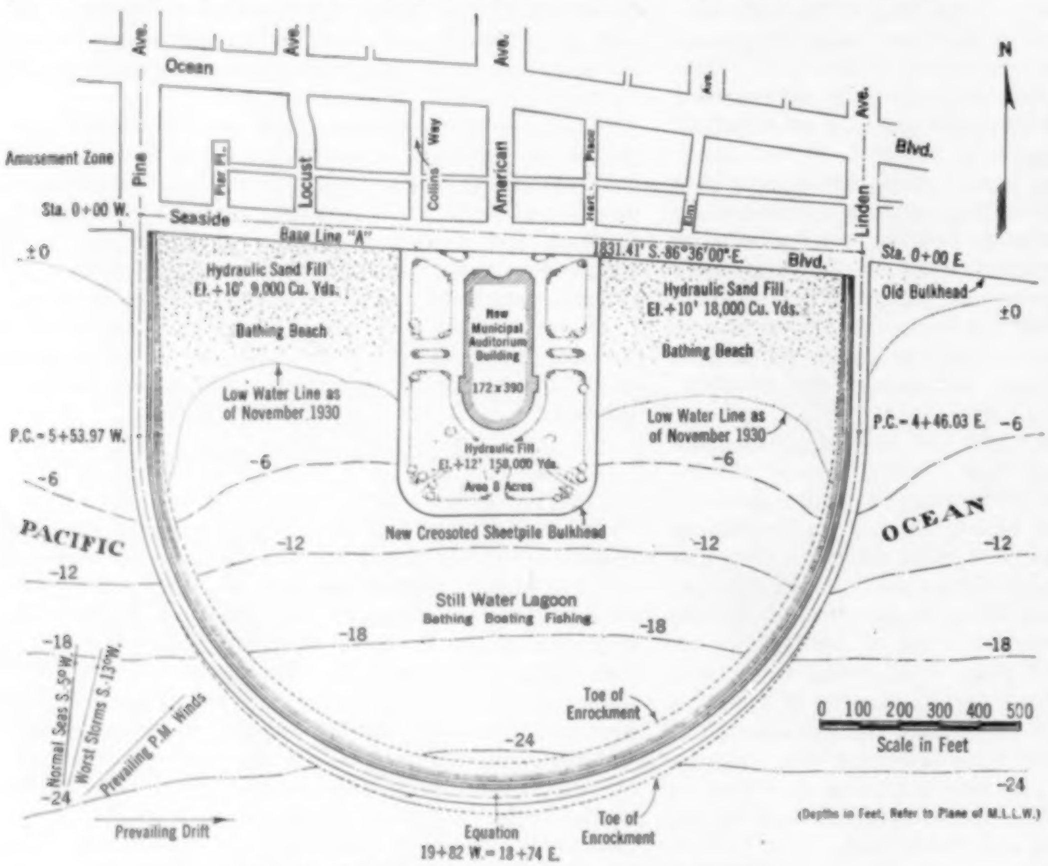

FIG. 1. COMPLETION PLAN, RAINBOW PLEASURE PIER
Long Beach, Calif.

ture against the "weaving" which often loosens the anchorage of timbers in seagoing piers and trestle structures. The pier, in turn, forms a safe and accessible approach for the delivery of stone to the enrockment when repairs are needed—but this is a condition that would not be likely to arise had the protective works been in contact with, or in combination with, the structure retaining the auditorium fill. The convex seaward exposure of the enrockment tends to deflect the progress of débris floating on the ocean before it comes into contact with the piles of the trestle, even though the crest of the stone structure is shoreward of the piles of the pier.

Placing of granite from Ormond Quarry near Riverside, Calif., was begun in March 1929, and was continued at a rapid rate until the enclosure of the sheltered water area was sufficiently complete to permit construction of the retaining bulkhead surrounding the auditorium site. This was completed in a working period of eight months. Stone was delivered in standard gage cars on the contractor's construction tracks, which had been laid along the shoreward side of the trestle in connection with the construction of the pier substructure.

RETAINING BULKHEAD AROUND AUDITORIUM SITE

The bulkhead to retain the hydraulic fill for the auditorium building and grounds encloses a submerged area 500 ft. wide extending about 690 ft. seaward from Seaside Boulevard (Fig. 1). The bulkhead forming three sides of the reclamation is about 1,800 ft. in length, and depths of water in which it was built vary from 11 ft. at mean low water to beach level. The top of the bulkhead is 12 ft. above mean lower low water, as is also the approximate elevation of the surface of the hydraulic fill which it impounds.

Panels of the bulkhead, 6 ft. in length, consist of two round guide piles and one round anchor pile driven to penetrations of 18 to 24 ft. The shoreward guide pile of each panel is sway-braced to the corresponding anchor pile, 14 ft. distant, with 3- by 16-in. timbers. Guide piles support a double row of 12- by 16-in. wales between which standard Wakefield sheathing is driven. Each Wakefield sheet pile is of one 4- by 16-in. and two 3- by 16-in. timbers of sufficient lengths to provide from 12 to 16 ft. of penetration. All timber used in the structure is creosoted, and all members are bolted to develop the strength of the member secured.

HYDRAULIC FILL FROM HARBOR DREDGING

The eight-acre area inclosed by the bulkhead just described was raised to an elevation of 12 ft. above mean lower low water by the deposit of hydraulic fill from Long Beach harbor to form the auditorium site and grounds. The deposit of dredged material was undertaken in December 1929, from a 24-in. suction dredge operating in channel No. 3 of Long Beach inner harbor. The length of pipe line through which the pump of the dredge delivered the material varied from 8,200 to 10,100 ft. No auxiliary pumping system was employed. The total quantity of hydraulic fill placed was approximately 185,000 cu. yd.

In connection with the deposit of fill within the bulkheaded area, the hydraulic fill along the beach within the inclosure of the pier enrockment was impounded behind temporary retainers which were removed after the fill had hardened. The beach area thus provided is 10 ft. above mean lower low water and 165 ft. wide.

STORM DRAIN

Before that part of the ocean front now forming the still-water lagoon was enclosed, storm waters from the section of the city immediately shoreward had emptied into the sea from storm drain extensions along the streets footing at the ocean. An intercepting drain paralleling Seaside Boulevard to carry storm waters into outfall mains outside the lagoon was therefore incidental to the general plan of improvement. Construction of these drains was effected under an independent contract entered into at a stage of progress under the general contract that would not interfere with bulkheading and dredging operations.

ENTIRE EXPENDITURE JUSTIFIED

All of the facilities for public use in the general plan of improvement, in addition to providing protection to the ocean front against encroaching seas, will prove of great value as municipal improvements. The pier itself, used under proper control of vehicular and pedestrian traffic, will appeal to a class of pleasure seekers not prone to the patronage of concessions usually found on seagoing stub pleasure piers. The still-water lagoon with its artificially widened bathing beaches has, even

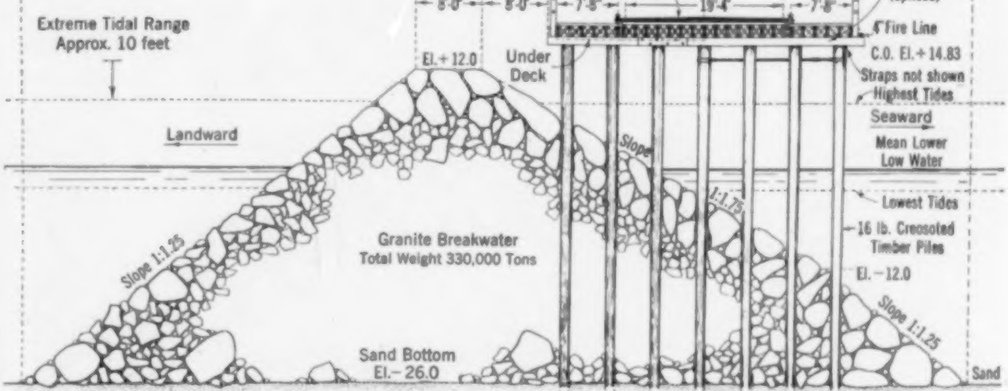

FIG. 2. TYPICAL CROSS SECTION AT CENTER OF CURVE
Rainbow Pleasure Pier

during the construction period, proved to be most attractive to the public as a swimming pool and recreational center.

CRITICISMS PROVE UNFOUNDED

Not only are the waters of the lagoon clear and clean, but the enrockment has already proved effective in screening floating débris and even oil from entrance to the lagoon from the ocean surface; and the beach slopes, without the surf usual on exposed ocean beaches, have proved attractive to pleasure seekers. Had the creation of the eight-acre tract as a site for the auditorium building been the sole advantage to be gained by the project, it would still have justified the total expenditure, for investigation prior to the submission to the bond issue developed the fact that an equal fund would only purchase a smaller and less centrally located site than is provided in this project.

Although the design required nothing more than the application of principles involved in ordinary harbor-improvement work, these same principles, when applied to the design of various units of this subproject, prompted many criticisms during the period when the bond issue was under public consideration and during the early stages of construction of the pier. Completion of construction has quieted these criticisms, the most persistent of which was the prediction that the still-water lagoon would become stagnant and unsuitable for bathing.

Design was, of course, based upon the certainty of two tidal replacements of half the high tide capacity of the lagoon every 24 hours. Another popular impression was that the enrockment should have been seaward of the pier trestle instead of landward from it as planned and constructed. However, observation of the behavior of the seas during periods of storms since the practical completion of both pier and enrockment has forced a revision of views on the part of those formerly offering criticism.

ACKNOWLEDGMENTS

A contract for the construction of the pleasure pier and its enrockment, and the construction of the bulkhead to retain the auditorium fill and the deposit of hydraulic fill, both within the enclosure of the bulkhead surrounding the auditorium site and along the beach within the enclosure of the enrockment, was made with the Hauser Construction Company on September 4, 1928. Construction of the subproject has been under the jurisdiction of the Department of Public Service, City of Long Beach, of which Arthur H. Adams, M. Am. Soc. C.E., is director and under whose supervision plans were prepared. The engineering firm of Leeds and Barnard, Los Angeles, approved the plans in a consulting capacity, and direct responsibility for both the preparation of plans and specifications and the supervision of construction has been intrusted to me since the inception of the project.

LONG BEACH WATERFRONT SHOWING RAINBOW PIER, LAGOON, AND EIGHT-ACRE MUNICIPAL AUDITORIUM SITE COMPLETE
The Old Straight Pier and Auditorium Lie Along the Far Leg of the Horseshoe

HINTS THAT HELP

Today's Expedient—Tomorrow's Rule

The minutiae of every-day experience comprise a store of knowledge upon which we depend for growth as individuals and as a profession. This department, designed to contain practical or ingenious suggestions from young and old alike, should afford general pleasure not unmixed with profit.

Designing Riveted Connections with Charts and Tables

By Odd Albert

Structural Engineer, East Orange, N.J.
Former Professor in Mathematics, West College, Sweden

As THE result of ten years of designing structures in this and other countries, numerous diagrams and tables have been developed. Here reproduced are several which simplify the detail so that riveted connections may be quickly designed without referring back to formulas and theory.

SHEAR AND BEARING

Assuming that the load is equally distributed among the rivets, a riveted connection must be designed so that

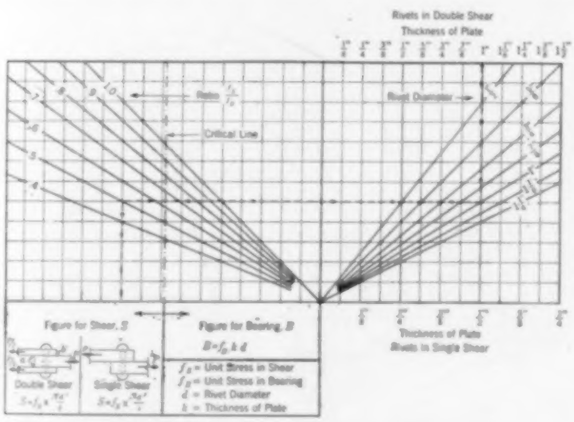

Fig. 1. Shear or Bearing Diagram

the rivets will neither shear off under the loads applied nor tear through some of the connected parts because of insufficient bearing. By the use of the chart in Fig. 1 it is possible to determine at once whether the joint design should be based on shear or bearing. For example, a connection design uses 1-in. rivets in double shear with a plate thickness of 1 in., $f_S = 10{,}000$, and $f_B = 20{,}000$ lb. per sq. in. Shall the design be based on shear or bearing?

Entering the chart, Fig. 1, at the 1-in. plate thickness, and following the arrows on the dotted line downward to the 1-in. rivet diameter, then left to ratio $\frac{f_S}{f_B} = 0.5$, the last intersection is found to the left of the "critical line," which indicates that the design must be based on shear. If, for example, the ratio $\frac{f_S}{f_B}$ being used were 0.7, the last intersection would be found to the right of the critical line and the joint design must then be based on bearing.

In the chart, Fig. 2, the bearing stress on a rivet under a given condition may be determined directly. For example, with a plate thickness, $k = \frac{1}{2}$ in., and an allow-

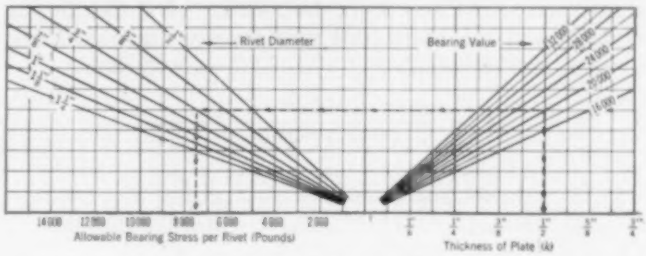

Fig. 2. Rivet Bearing Diagram

able rivet bearing stress of 20,000 lb. per sq. in., it is required to find the bearing stress on a $^3/_4$-in. rivet. Enter Fig. 2 at plate thickness, $k = \frac{1}{2}$ in., follow arrows on dotted line upward, turn left at $f_B = 20{,}000$ lb. per sq. in., turn down at $d = {}^3/_4$ in., and read 7,500 lb., the allowable bearing load for each $^3/_4$-in. rivet. In a similar manner the example in Fig. 3 gives directly that the shearing load supported by a 1-in. rivet in single shear is 9,400 lb. when $f_S = 12{,}000$ lb. per sq. in.

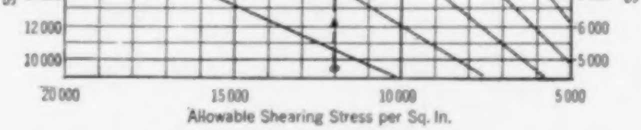

Fig. 3. Rivet Shear Diagram

The number of rivets required in this kind of connection is then determined by the formula:

$$W = NS. \qquad [1]$$

where W = the load, N = the number of rivets, and S = the stress per rivet.

ECCENTRIC CONNECTIONS

In the eccentric connections it is assumed that the direct shear caused by the load is equally distributed among the rivets and that the rivets receive an additional torsion shear varying with the distance of the rivet from

the center of gravity of the group. The following formula gives the maximum resultant rivet stress on an extreme rivet:

$$S = \frac{W}{N}\sqrt{A^2B + A + 1} \quad . \quad . \quad [2]$$

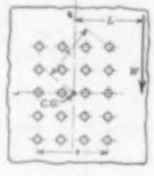

FIG. 4

$$\text{with } A = \frac{LNe}{I}, \text{ and } B = \frac{r^2}{e^2}$$

where W = the eccentric load, N = the total number of rivets, and I = the polar moment of inertia of the rivet group. See Fig. 4 for other values.

If the rivets are symmetrically arranged, the expressions A and B become more simplified. If, therefore, the vertical and the horizontal spacings are assumed to be a and b, and the number of vertical rows is R, then

$$A = \frac{12Lb(R - 1)}{a^2(n^2 - 1) + b^2(R^2 - 1)^2}$$

$$B = \frac{a^2(n - 1)^2 + b^2(R - 1)^2}{4b^2(R - 1)^2}$$

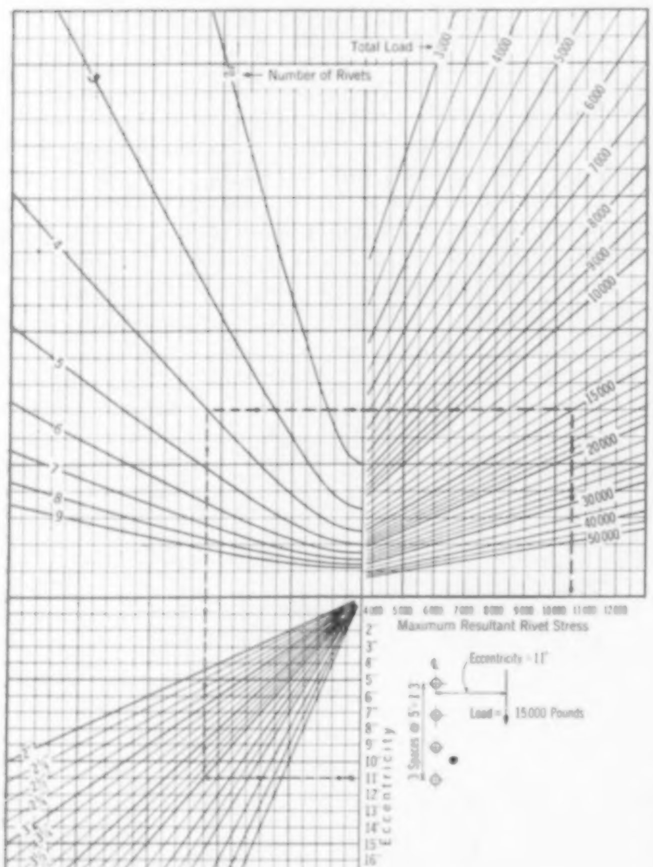

FIG. 5. ECCENTRIC RIVET CONNECTIONS
One Row of Rivets

It will be noted that these expressions are easily solved because every item can be taken directly without prefiguring.

The above expressions can be further simplified if the number of vertical rows is known and the spacing a equals the spacing b. As this is usually the case, the following table for the values of A and B may be used.

TABLE I. VALUES OF A AND B

NUMBER OF VERTICAL ROWS	A	B	VALUES
2	$\frac{12L}{b(n^2 + 2)}$	$\frac{(n-1)^2 + 1}{4}$	L = eccentricity
3	$\frac{24L}{b(n^2 + 7)}$	$\frac{(n-1)^2 + 4}{16}$	b = rivet spacing
4	$\frac{36L}{b(n^2 + 14)}$	$\frac{(n-1)^2 + 9}{36}$	n = number of rivets in one vertical row

It will be noted that these expressions are extremely simple and only contain three variables.

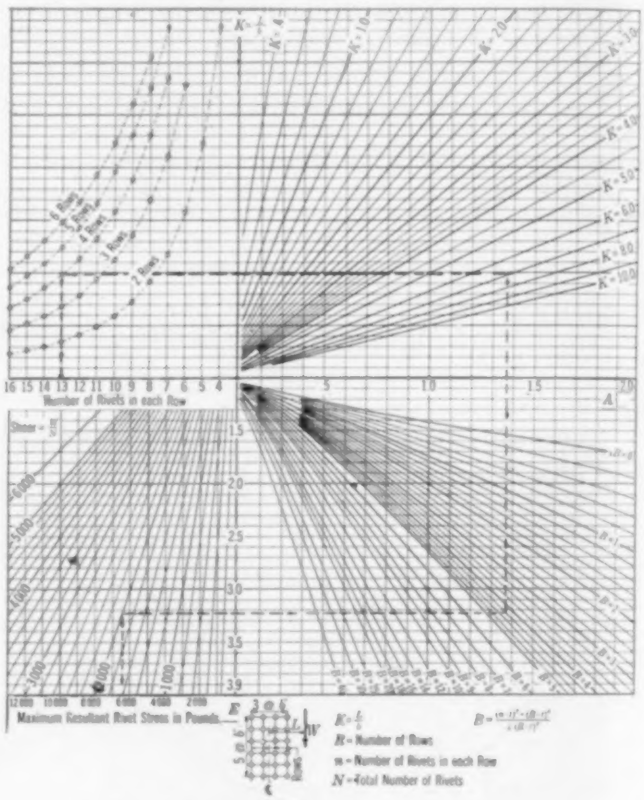

FIG. 6. ECCENTRIC RIVET CONNECTIONS
More Than One Row of Rivets

In the chart, Fig. 5, the stress per rivet may be directly determined for an eccentric load carried by a single row of rivets. The example, shown by the dotted lines, indicates the method of using the chart. A row of 4 rivets with 5-in. spacing carries an eccentric load of 15,000 lb., with an eccentricity of 11 in. Enter the chart at L = 11 in., turn up for spacing of 5 in., turn right for 4 rivets, turn down at total load of 15,000 lb.; then the maximum resultant rivet stress is 10,600 lb.

Where the eccentric load is carried by more than one row of rivets, the use of the chart in Fig. 6 readily gives the maximum resultant stress per rivet. A connection of 52 rivets in 4 rows (rivet spacing 4 in.) carries a load of 104,000 lb., with an eccentricity of 28 in. Enter the chart at n = 13 rivets, turn right at 4 rows, turn down for the ratio $k = \frac{28}{4} = 7$, turn left for B =

Table II. Value of B

No. of Rows	Number of Rivets in Each Vertical Row, n: 4	5	6	7	8	9	10	11	12	13	14	15	16
2	2.50	4.25	6.50	9.25	12.50	16.25	20.50	25.25	30.50	36.25	42.50	49.25	56.50
3	0.81	1.25	1.81	2.50	3.31	4.25	5.31	6.50	7.81	9.25	10.82	12.50	14.31
4	0.50	0.69	0.94	1.25	1.61	2.03	2.50	3.03	3.61	4.25	4.95	5.70	6.50
5	0.39	0.50	0.64	0.81	1.02	1.25	1.52	1.81	2.14	2.50	2.80	3.31	3.77
6	0.36	0.41	0.50	0.61	0.74	0.89	1.06	1.25	1.46	1.69	1.94	2.21	2.50

4.25 (from Table II), turn down for shear $= \dfrac{104{,}000}{52} =$ 2,000, and read 6,450 lb., the stress on the rivet carrying the maximum load.

To check the result obtained from the chart, obtain values of A and B by the use of Table I, substitute in Formula 1, and solve for S.

$$A = \frac{36 \times 28}{4(13^2 + 14)} = 1.377,$$

$$B = \frac{(13-1)^2 + 9}{36} = 4.25,$$

and

$$S = \frac{104{,}000}{52} \sqrt{1.377^2 \times 4.25 + 1.377 + 1}$$
$$= 6{,}450 \text{ lb.}$$

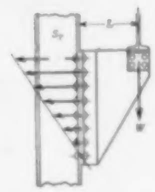

Fig. 7. Typical Bracket Connection

Rivets in Tension

For rivets in tension the assumption is made that the center of rotation is at the bottom rivet and that the other rivets will receive tensile stresses which are in direct proportion to their distances from this center of rotation.

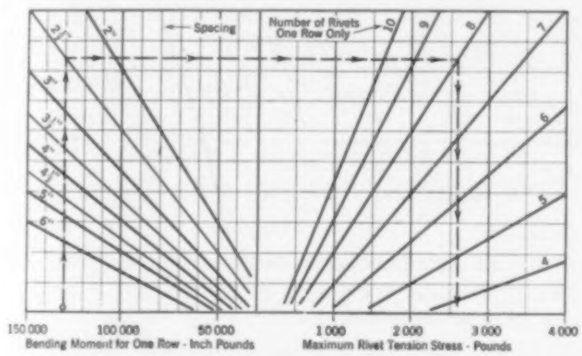

Fig. 8. Rivet Tension Diagram

If a bracket connection, as shown in Fig. 7, is to be used, it will be seen that some of the rivets are stressed in tension in addition to being stressed in shear and bearing. It is assumed that the presence of a tensile stress in a rivet does not affect its value of shear resistance or vice versa.

It can be proven that the maximum tensile stress is given by the formula:

$$S_T = \frac{6M}{an(2n-1)}, \quad . \quad . \quad . \quad . \quad [3]$$

where M = the moment in inch-pounds per one vertical row,

n = the number of rivets in the row, and

a = the vertical rivet spacing.

The diagram in Fig. 8 gives the maximum tensile rivet stress for one vertical row of rivets. For example, consider a moment of 260,000 in-lb. taken by a bracket with 2 rows of rivets, 8 rivets in each row. Rivet spacing is $2^1/_2$ in. The moment for one row is $^1/_2 \times 260{,}000 =$ 130,000. Enter the diagram at M = 130,000; follow the dotted line; turn left for spacing = $2^1/_2$ in.; turn down for 8 rivets; and read 2,600 lb.

Checking by the use of Formula 2, we get

$$S_T = \frac{3 \times 260{,}000}{2.5 \times 8\,(16-1)} = 2{,}600 \text{ lb.}$$

Loading Test on Wooden Bowstring Truss

By Conrad E. Pantke
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Structural Engineer, New York, N.Y.

Wooden bowstring trusses have been popular for a great number of years, especially in Los Angeles, Chicago, and New York. They are widely used for commercial and industrial buildings because of their low cost and almost instant availability. The theoretical stress analysis follows the usual methods of accepted engineering practice and is not disputed. In fact, there would be nothing sufficiently uncertain about these trusses to necessitate the test here described except that they are built of wood.

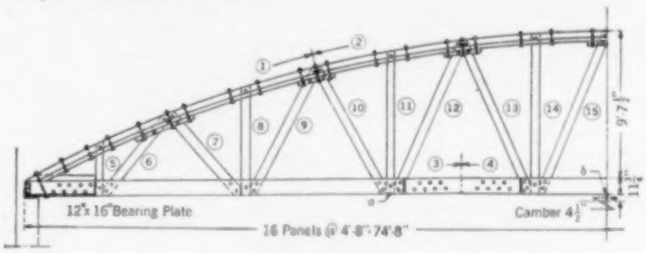


Fig. 1. Wooden Bowstring Truss, 75-Ft. Span

Wood as a structural material has been greatly neglected. Whereas intensive research work with other structural materials has created generally accepted strength values, opinions as to the strength of wood or its connections differ in a grotesque way. For instance, the St. Louis Building Code values the permissible tension stress of Douglas fir at 1,800 lb. per sq. in., but the same piece of lumber, according to the New York Building Code, is worth only 800 lb. per sq. in. While opinion is practically unanimous as to the strength of a rivet in steel construction, no authoritative commitment seems to be available as to the strength of a bolt connection in timber construction.

This situation is now being remedied. Grading and rating of timbers as described by Chester J. Hogue,

M. Am. Soc. C.E., in the July 1930 issue of *Engineering News-Record*, makes it possible to economically obtain a practically uniform timber of definite, predetermined strength. Furthermore, authoritative tests now being conducted will assign definite strength values to various types of timber connections.

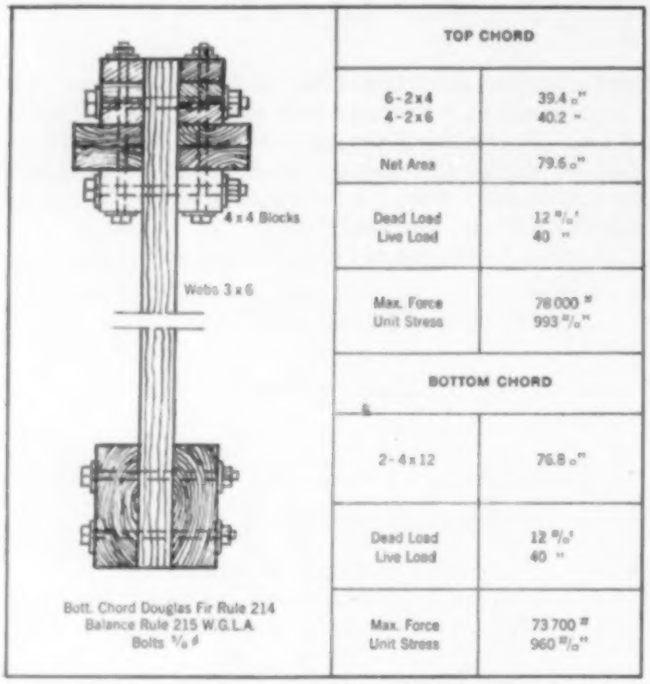


FIG. 2. DETAIL OF CHORD MEMBERS

The following test, however, has no relation to the above mentioned research; it became necessary in order to prove before the New York Building Department the soundness of a wooden bowstring truss design for which a permit had been asked. The necessity of this test had not been foreseen by the contractor and became known to him only when the assembly of the trusses had practically been completed. This eliminated the possibility of extraordinary care in the selection of the lumber or in the workmanship. Therefore the truss which was tested may be fairly considered as representative of the quality which may be obtained in practice under ordinary conditions. This design is shown by Figs. 1, 2, and 3.

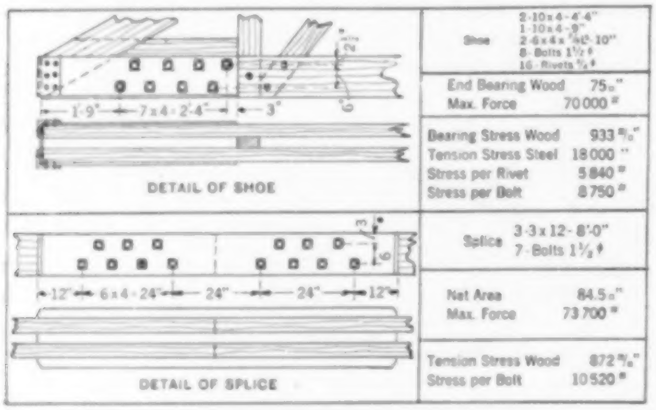


FIG. 3. DETAIL OF SHOES AND SPLICES

The truss is of 75-ft. span on a spacing of 20 ft. Twice the prescribed live load of 40 lb. per sq. ft. was imposed, making a total of 120,000 lb. In addition, the truss carried a dead load of 10 lb. per sq. ft., which brings the total load up to 135,000 lb. The test arrangement is shown by Fig. 4.

This test was conducted on the building site by the contractor, the Summerbell Truss Company of New York under the direction of the Building Department of the Borough of Manhattan. There were also present representatives from building departments of the other boroughs of the city, representatives of the National Lumber Manufacturers Association and the West Coast Lumberman's Association, as well as the architect who had specified the trusses and I, who was responsible for their design.

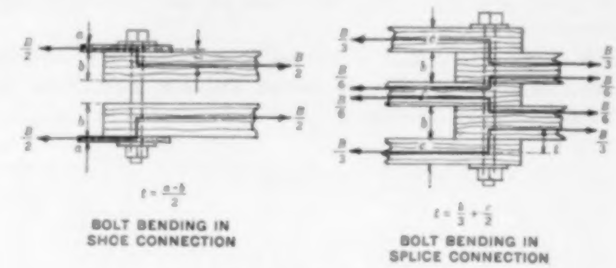


FIG. 4. ARRANGEMENT OF TEST

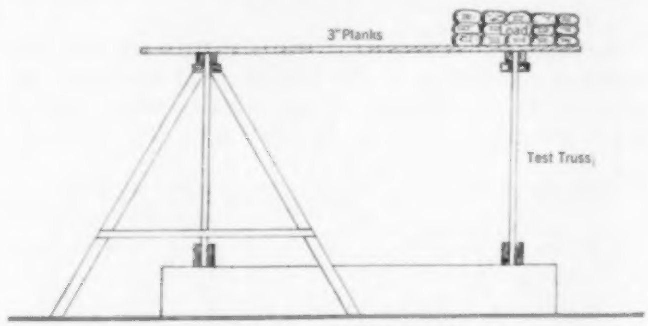


FIG. 5. STRESS FLOW THROUGH BOLTED CONNECTIONS

Before the test started, the lengths of all members were measured. Then the load was imposed in three stages: first, 60,000 lb., then an additional 34,000 lb., and eventually the balance of 26,000 lb. An intermission of 24 hours was interposed between the second and third stage. Each time deflection measurements were taken at three points of the bottom chord, a, b, and a', indicated in Fig. 1. Also, the lengths of all members were measured again under the full load. Finally, the load was removed and the remaining deflections were measured.

Wooden trusses are, as a matter of course, subject to

TABLE I. LOADS, STRESSES, AND DEFLECTIONS

	THEORETICAL UNIT STRESS IN LB. PER SQ. IN.		DEFLECTIONS IN IN. BOTTOM CHORD		
LOAD ON TRUSS IN LB.	TOP CHORD Compression	BOTTOM CHORD Tension	a	b	a'
Dead load of 15,000 lb.	191	185	0	0	0
Dead load plus 60,000 lb. live load.	955	923	2	2 3/8	1 3/4
Dead load plus 94,000 lb. live load.	1,388	1,340	3	3 3/4	2 7/8
Same as above, but 24 hours later	1,388	1,340	3 1/2	4 1/8	3 1/4
Dead load plus 120,000 lb. live load	1,720	1,660	4 1/2	5 3/8	4 3/8
Dead load only (live load removed)	191	185	2 1/4	2 3/4	2 1/8

some yield in the connections until the bolts develop their full bearing. This accounts for the increase in deflection at the center of the span during the intermission of 24 hours, of from $3\frac{3}{4}$ in. to $4\frac{1}{8}$ in. It also accounts for the deflection of $2\frac{3}{4}$ in. remaining after removing the load, which was amply provided for by the $4\frac{1}{2}$-in. camber.

THE TEST, 135,000-LB. TOTAL LOAD

The maximum deflection of the truss under twice the prescribed live load, including the 24-hr. intermission, was $5\frac{3}{8}$ in., or $\frac{1}{108}$ of the span. It therefore may be assumed that, under normal conditions, the deflection would not exceed about $\frac{1}{380}$ of the span. Web members did not change their length, except one post and two diagonals nearest the ends. This conforms with the theoretical stress analysis, according to which stresses in the web members are very small. The original design provided only one-bolt connections for the diagonals, and the test seems to indicate that this would have been sufficient except possibly for the first two diagonals nearest the ends.

Another change in the original design was made in the shoe. It had been intended to use a bent flat iron shoe, 10 by $\frac{3}{8}$ in., consisting of only one piece. Model tests which had previously been made would indicate that such a shoe is more satisfactory than the riveted shoe used for this full size test. Naturally, the riveted shoe was subject to considerable bending moments on account of the sharp corners, and after the test it showed a noticeable permanent deformation. The objection raised against the flat iron shoe was that its strength may be impaired during the process of bending in the shop and that, in ordinary building practice, this defect may escape notice.

The bolts were designed for bearing and bending. Usually the permissible bending value is the limiting factor in the design of bolts in timber connections. This bending value was figured according to the following formula:

$$B = 2{,}650 \times \frac{nd^3}{t},$$

in which B = working value of bolt in pounds, limited by bending

d = diameter of bolt in inches

t = lever arm of bending moment in inches

n = number of splice plates (2 for shoe, 3 for bottom chord splice)

The assumed flow of the stresses and the lever arms, t, are illustrated by Fig. 5. Some of the bolts were removed after the test and inspected. No deformation was visible, indicating that this formula renders sufficiently conservative values. The results of the test were considered satisfactory and a formal permit was issued by the New York City Building Department.

Rapid Calculation for Reservoir Discharge

By R. D. GOODRICH

MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS

PROFESSOR OF CIVIL ENGINEERING, UNIVERSITY OF WYOMING

It is usually impractical to make an exact determination of the discharge over a spillway or through uncontrolled outlets when a flood passes through a reservoir or a detention basin with contracted outlet channel. Especially is this the case when the outflow may be through culverts and over one or more spillways in addition to the usual conditions of variable inflow and a non-prismatic reservoir.

Heretofore the ordinary solution of this problem, as described in handbooks dealing with hydraulic problems, has been made by methods of trial and error involving the computation or plotting of mass curves of inflow and outflow. The following method for an approximate solution was developed to avoid the long computations and increasing size of the numbers involved in mass computations and also to give direct answers as to the outflow and storage at the end of each successive day or period of the flow, without the use of approximations as in trial and error methods. It has been used in the U.S. Engineer Office, Sacramento District, with satisfactory results and very material savings in labor and time, in connection with an investigation of the Sacramento Flood Control Project, and may be useful in other studies which require the routing of many individual floods through reservoirs with any given outlet conditions.

The solution assumes that curves are available, giving the storage capacity of the reservoir and the discharge of the outlets for any elevation of the water surface within the range of the maximum flood to be computed. It is also assumed that the inflow is tabulated for regular time intervals, as is usually the case, and that their length is so short that the change in the rates of inflow and outflow may be considered as uniform during each period. In the example used as an illustration, the time periods are taken for convenience as 24 hours, and a flow of 1 cu. ft. per sec. is taken equal to 2 acre-ft. for this period. This factor for conversion from standard flow to storage

units is very commonly accepted and is usually more accurate than the ordinary data on floods. It is evident that, for any given period of the flood, the volume stored in the reservoir at the beginning, plus the inflow during the period, must be equal to the outflow plus the volume remaining in storage at the end of the same period.

Let S_1, F_1, and Q_1 be respectively the storage in acre-feet and the inflow and outflow rates in second-feet at the beginning of any of the equal periods into which the entire flood is divided; and S_2, F_2, and Q_2 be the values for the same quantities for the end of the same period.

Then,

$$S_1 + F_1 + F_2 = Q_1 + Q_2 + S_2.$$

The computation is started with some period at the beginning of the flood for which F_1 and F_2 are known,

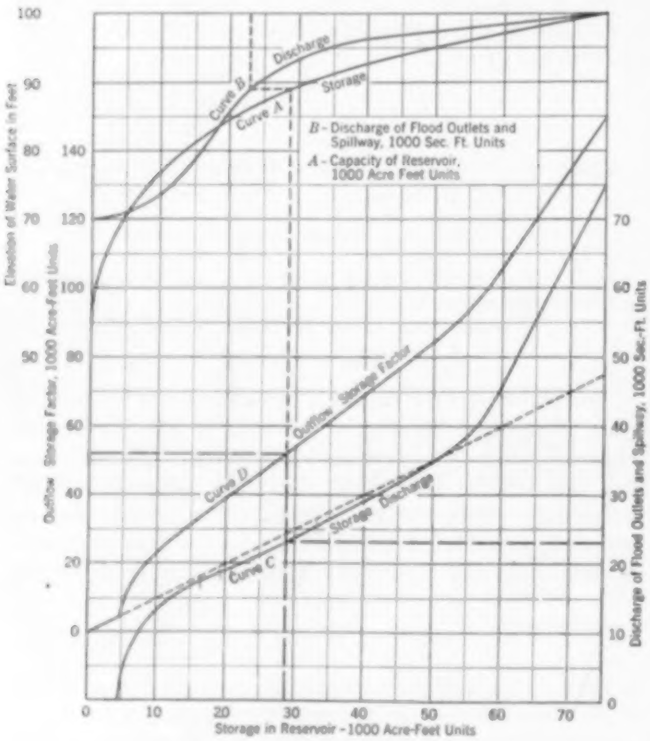


FIG. 1. STORAGE DISCHARGE CURVES

and with the reservoir filled to the level of the outlets, in which case Q_1 will be zero, and S_1 can be determined from the reservoir capacity curve. The computation may also be started with known outflow and storage or with a small rate of outflow assumed equal to the inflow at the beginning of the flood.

In any case, for the first period it is necessary to know the values of the first four of the six quantities in the above equation. If the two remaining quantities can be determined directly from the value of a factor computed by means of the first four, then all the quantities will be known for the end of the first period and the beginning of the second period. The quantities necessary for the computation of the factor and the determination of the outflow and storage at the end of the second period will then be known and the problem may be solved by the computations for each successive period. With the above method of solution in mind, write the known quantities for any period of the flood on the left side of the equation, thus:

$$F_1 + F_2 + S_1 - Q_1 = S_2 + Q_2$$

The quantity, $S_2 + Q_2$, represents the "outflow-storage factor," for any stage of the reservoir; S_2, at the end of any period. Its value is to be computed from the values of the four quantities which are always known for the beginning of the period.

Two curves can easily be plotted from the capacity and discharge curves for any reservoir and outlets, to give directly the values of the two unknowns for any value computed for the outflow-storage factor. The construction and use of these curves will be illustrated by an example. Suppose that the storage and discharge at any stage in a given reservoir are given by the curves A and B at the top of the diagram, Fig. 1. Curve C is plotted in the usual way to give the relation of storage and outflow at any stage of water in the reservoir during floods, and using the same scales for storage and discharge as for the first curve. That is, the ordinate to any point on Curve C is equal to the abscissa to Curve B at the extension of this ordinate vertically to Curve A, and horizontally to Curve B.

Curve D, the "outflow-storage factor curve," is plotted by the aid of the inclined dotted line. The ordinate to any point on the dotted line has the same value on the outflow-storage factor scale as the abscissa at the foot of that ordinate has on the storage scale at the top and bottom of the diagram. Since the length of a unit on the outflow-storage factor scale is half that on the storage scale, the slope of the dotted line with reference to the horizontal axis is 0.5. Using this same scale ratio, with proportional dividers, one-half the height to Curve C is laid off on any ordinate above the dotted line to give the corresponding point on Curve D. In this way enough points are plotted to draw a smooth curve for the outflow-storage factor relation.

To illustrate the use of these curves, assume that a flood has just filled the reservoir to the level of the invert of the lowest of a series of culverts, and that the discharge, Curve B, gives the combined discharge of all the outlet culverts together with a spillway at higher elevation. Let the flood be as shown in Table I, with rates of discharge given for intervals of 24 hours, beginning with the instant that outflow starts. The units for the computations are in thousands.

TABLE I. DISCHARGE CALCULATIONS

PERIODS	1	2	3	4	5	6
Inflow F_1	10.5	37.0	93.2	43.5	62.8	25.7
Inflow F_2	37.0	93.2	43.5	62.8	25.7	——
Storage S_1	4.5	28.9	70.2	72.0	61.1	58.5
Sum	52.0	159.1	206.9	178.3	149.6	——
Outflow Q_1	0.0	23.1	65.7	69.2	48.1	43.0
Outflow-storage factor	52.0	136.0	141.2	109.1	101.5	

With inflows at the beginning of each 24-hour period, as indicated in the second line of the table, the first step in computing the first outflow-storage factor is to set down in the column for the first period the known ~~outflow~~ inflow, 37.0, for the end of the period. From Curve C it is seen that the storage is 4,500 at the instant outflow starts, and this figure is also entered in this column. The sum of the three items in the column is 52.0, and since the outflow is zero, this is the value of the required factor.

Enter the diagram at the left with this value and pass horizontally to Curve D, as indicated by the heavy line. From this point follow the ordinate down to its intersection with Curve C, and the coordinates of this point give the storage and outflow at the end of the period as 28,900 acre-ft. and 23,100 sec-ft., respectively. These quantities are entered in their proper lines for the second period and, with the inflow of 93.2 added for the end of that period, all the items have been determined for the computation of the factor for the second period. The diagram used was drawn on an $8^1/_2 \times 11$-in. sheet of cross section paper divided 20 lines to the inch. and the computation was completed in less than 15 minutes.

Errors computed after the work was finished show that the maximum error is less than 1 per cent if divided equally between the storage and discharge. With large scale diagrams it should be possible to secure any degree of accuracy warranted by the data. The accuracy of the results is, of course, very largely dependent upon the length of the time intervals used. For 12-hour periods, the height of Curve D above the dotted line would be reduced one-half, for 6-hour periods it would be reduced by three-quarters.

To interpolate for periods of any length the distance between Curve D and the dotted line on any ordinate could be divided into 12 parts and enough ordinates may be so divided to draw curves for periods varying by 2 hours and from 2 to 24 hours in length. Any engineer competent to use the method should be able to make the necessary modifications in the formula. The formula can easily be altered for use with other flow or storage units and it is hoped that it may prove useful in other similar investigations.

Sand Trap for Canals Works on Vortex Principle

By R. L. PARSHALL

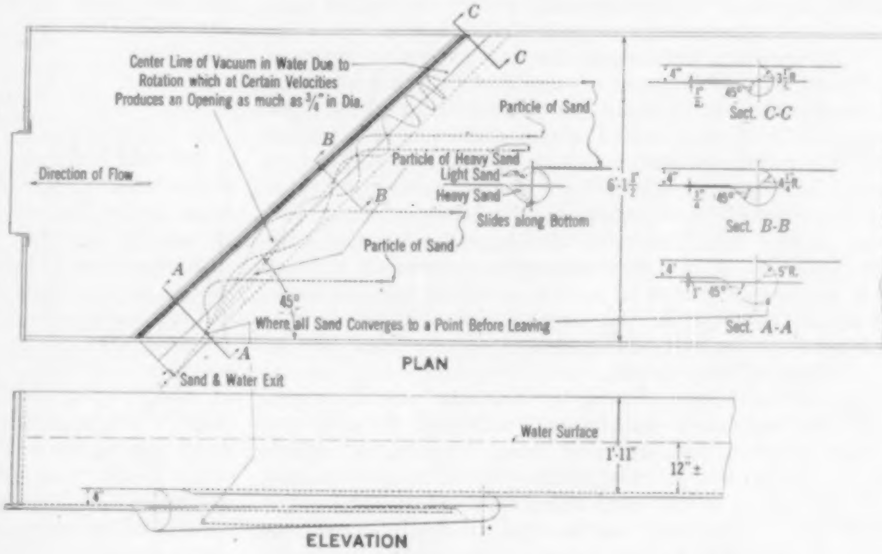
ASSOCIATE MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
IRRIGATION ENGINEER, U.S. DEPARTMENT OF AGRICULTURE, FORT COLLINS, COLO.

ONE of the problems in connection with the operation of irrigation and power canals has been to dispose of sand and gravels that enter the headgates. Various types of sand traps have been prepared with varying degrees of success and failure. A so-called vortex sand trap has been developed as a result of experimental work in the hydraulic laboratories at Fort Collins, Colo. The accompanying drawing shows the general arrangement.

In its basic principle, it involves the creation of a horizontal vortex in an expanding tube of special section placed diagonally across the bottom of the channel at about a 53-deg. angle. A violent rotation of the water is produced in the direction of this tube, the rotation at the top of the vortex being in the direction of the flow in the channel. The expanding tube leads outside of the conduit and the water discharged by it disposes of practically all of the debris that is carried along near the bottom of the canal by the water. The channel below the vortex is depressed a certain amount, depending on the size, depth, and velocity of water.

Observations have been made of the rate of rotation, as well as the translation velocities within the expanding tube. These have been expressed as a function of the mean velocities of the stream passing over the tube. For a mean velocity of between $2^1/_2$ and 3 ft. per sec., rotations as high as 200 r. p. m. have been observed. The effect of this rapid rotation is to create a vortex in the center of the tube and a strong suctional effect on sand and debris coming within its influence. Fine sand, silts, and cobblestones weighing from 3 to 5 lb. have thus been ejected from the experimental flumes by this device.

Another method that has been investigated is that in which cross currents are set up by means of riffles or cleats on the bed of the channel, placed at various angles and variously disposed. It has been demonstrated that it is possible to set up such currents by these riffles that practically the entire bed load of the channel can be diverted almost at right angles to the axis of the stream. It is believed that such riffles, in combination with the vortex sand trap, will be effective in eliminating practically all of the moving bed load in the channel. The investigations that have led to the development of this device were made under a cooperative agreement between the United States Department of Agriculture, Division of Agricultural Engineering, and the Colorado Experiment Station at Fort Collins, Colo.



VORTEX SAND TRAP DEVELOPED AT THE FORT COLLINS LABORATORIES

period. With the above method of solution in mind, flow is zero, this is the value of the required factor.

OUR READERS SAY—

In Comment on Papers, Society Affairs, and Related Professional Interests

Cincinnati Unifies Its Terminals

Dear Sir: While the paper by Col. F. G. Jonah, in the January issue, treats mainly of the coordination of passenger and freight railway terminals for our representative inland cities, it does suggest the further possibility of complete coordination of our modern methods of supplementary transportation—the automobile, bus, coach, and airplane—with that by rail; and likewise, in a more limited way, with water terminals.

Proposed Cincinnati Union Terminal

According to theory, every transportation means should be located in convenient proximity to every other. Practically, there is probably nowhere available the requisite area which could be economically utilized for a complete, coordinated terminal, to provide the necessary space and facilities for the several now-existing forms of transportation.

At Cincinnati, we have under construction a union passenger terminal which will be used by the seven railroads operating into and out of our city. It is located two miles from the business district, in an area which was largely below the flood stage of the Ohio River, and was used by the city and the public as a dump, although owned privately by railroads. Four of the seven railroads interested in the terminal project occupied portions of the selected site or passed through it.

At the present time there are five passenger stations in Cincinnati. Passenger service now handled by these five stations will be brought together at the new passenger terminal. Not only will the union passenger terminal facilitate passenger service, but it will be of equal or greater benefit to freight service in that passenger trains will be diverted to separate tracks leading to the terminal at the outer limits of this highly congested railroad district. A not uncommon occurrence at present is for passenger trains to arrive at Cincinnati on time, but owing to their having to pass through this bottleneck area, to be from five minutes to one hour late at the Central Union Depot.

Further, as the usual outgrowth of any large improvement, the railroads within and adjacent to the new station project are revising and modernizing their freight facilities. In particular, the Chesapeake and Ohio will erect a terminal warehouse estimated to cost $8,000,000. This will be a modern building of six stories occupying a city block. The railroad freight improvement program calls for expenditures of about $75,000,000. The union passenger terminal will cost $41,000,000, and will be completed during the summer of 1933.

Colonel Jonah's paper further refers to the possibility of unification of local freight receiving and delivery service. In this connection, the Cincinnati union passenger terminal project requires the property now occupied and used by the Baltimore and Ohio, the Big Four, and the Southern Railway System for three separated team track yards and freight stations. Under the new plan, the freight facilities of these three railroads will be moved to one location. Although each will have separate office and depot facilities, the receiving and forwarding point for local shippers has been centralized.

Air, water, and highway transportation are needed to form a coordinated transportation service. Thus far, however, these more recent transportation vehicles have been operating over improved right-of-ways, the capital expenditures for which have been from public funds. It is the usual practice on public improvement work for state and city governments to assess a percentage of the improvement cost to the property benefited. Therefore, transportation companies using these public improvements as a business enterprise should be assessed a just and equitable percentage of the improvement cost.

Coordination of terminals is possible:

1. If they are an economic transportation facility.
2. If public pride and prejudice will acquiesce to their location at a site other than in or adjacent to the central business district.
3. If each type of transportation be placed on an equal basis in regard to taxation, provision of right-of-ways, equipment, and similar items.
4. If one form of transportation is not subsidized to the disadvantage of another.

Henry M. Waite, M. Am. Soc. C.E.
Chief Engineer, Cincinnati Union Terminal

Cincinnati, Ohio
January 7, 1930

China Awake

To the Editor: Mr. Lane's recent articles, in Civil Engineering, on China prompt me to add my observations to the discussion of present conditions there. The leaven of learning and of modern science has made differences, and the signs of awakening are all about us. Those of us who live in China and have known the old are more fully aware of the changes that are everywhere taking place. Every city of any size is making roads and streets. When streets are built, some sort of sewer, even though it be the crudest, is attempted. Most cities in South China, of fifty thousand population or even less, have electric light plants.

Everywhere at least a modicum of attention is being given to the beginnings of sanitation. China's system of agriculture demands the use of nightsoil for fertilizer, so we do not anticipate that the American style of sewage disposal will prevail here for many generations, if ever.

But nightsoil buckets are now required to be covered. In my own city, the engineering department is beginning the installation of a kind of semi-sanitary fixture for the public toilets.

Real honors are due the public-spirited engineers of this new day in China, who have by a process of education and propaganda made the people actually want the improvements of our modern times.

Only a beginning has been made; but we believe that, the start having been accomplished, the movement cannot help but gather momentum rapidly. In fact, it is already doing so.

Paul P. Wiant, M. Am. Soc. C.E.
Fukien Construction Bureau

Foochow, China
December 4, 1930

More About Foundation Pressures

Dear Sir: Like all other engineers, I have been much impressed with the proposed details of the Hoover Dam as explained by Dr. Mead in the October issue of Civil Engineering. In particular, the question of foundations is important.

The 30 tons maximum foundation pressure used in the design of the Hoover Dam would indicate a factor of safety of ten as far as crushing failure is concerned. This however means little, since this dam would not fail by crushing of the material. It is true that the lower the foundation pressure is kept the safer will be the dam, but that is on account of the resulting wider base. The stress of 30 tons per sq. ft. will never be the limiting factor directly.

The adoption of a maximum working compressive stress as low as this (equivalent to 416 lb. per sq. in.) for such a large structure as the Hoover Dam practically excludes the use of any other type but a gravity dam. Still this low stress is no true indication of what the factor of safety may be.

Concrete is made better and more uniform today than it was 25 years ago, and a maximum working compressive stress of 30 tons per sq. ft. can today be considered low or very moderate. Good concrete in a dam is more important than the adoption of very low stresses.

Lars Jorgensen, M. Am. Soc. C.E.
Consulting Hydro-Electric Engineer

San Francisco, Calif.
December 11, 1930

The Thoroughfare Plan and Subdivision Control

To the Editor: It was a pleasure to read the very comprehensive and well thought out treatment of "Supervised Regional Expansion," by A. P. Greensfelder, in the January issue of Civil Engineering. Communities grow by increment, and if the surrounding region is not planned, each increment will simply add an unplanned area with all the inconsistencies and frictions resulting from lack of planning.

Political boundary lines are usually arbitrary. They are the heritage of an ancient habit of thought; they have taken the place of the walls of ancient cities. We have perpetuated these walls in an imaginary boundary line to protect us from imaginary enemies that become real enemies because they are on the other side of the line.

Any plan of a city or region must possess a very tangible economic or social value; otherwise it is no better than any politician can do and, while it may be possible to evolve a proper plan by "the mingling of men," "the meeting of minds," and the "merging of methods," the fundamentals must not be lost sight of in these compromises with unintelligent selfishness. Mr. Greensfelder rightly stresses the value of education in city planning.

In the St. Paul and Minneapolis region we have the ideal opportunity to superimpose a regional plan. Here are two metropolitan cities, one of 300,000 population and the other of 480,000 population with a number of satellite suburban developments. The business districts of each city are just 10 miles apart, connected by a fine highway 120 ft. in width, and the boundary line between the two cities is purely imaginary excepting to the precinct voter and taxpayer.

A voluntary regional planning association has been formed and through its efforts and that of the State Board of Health a Metropolitan Sanitary Commission was appointed by the legislature to solve the sewage disposal problems of the dual city. The sewers of the two cities begin at the boundary line between them and carry the flow east and west. There is a sewer system within the city limits of one city that lies in the drainage area of the other. A pumping plant has been installed to pump the sewage over the hills and keep it within its mother city.

The immobility of the human mind; the difficulty that the business man finds in thinking in clear terms of things outside of his business; the special interests which prefer the status quo to the uncertainty of a higher social and better economic life; self-centered political groups jealous of their powers; the suspicion of the small community that it will be swallowed in the maw of the greater one; the landowner who wants to sell his land for whatever use will bring the highest price—here is where education must begin.

This region should have a plan to guide the impulses of its 800,000 people in the right channel; they should not be permitted to move forward blindly. Planning has been a great adventure for those who knew that something should be done but were not certain what it was.

The connecting highway or thoroughfare plan comes first—transportation. Motor transport, automobiles, buses, electric lines, power lines, and telephone lines should have direct routes across the region; they are the distributors of food, lumber, raw material, finished products, power, thought, and people. The thoroughfare plan should be properly zoned as to use: the thoroughfare for motor transport and buses, a region way; another for automobiles, a parkway; and another for electric light, power lines, and telephone lines, a utility way.

This thoroughfare plan then becomes the plan of the land. It is the pattern of the region within which the mosaic of ownership must fit. It is the beginning of subdivision control.

With a plan, when a town-site plan or addition is recorded, the location and width of its major and minor streets, and the size of blocks and lots will become fixed forever. The plat will be inviolate, stamping a legal quality upon the land when it is recorded, and the pattern cannot be changed except through the power of eminent domain or a vacation order by the courts.

The regional planning ills of all communities are the result of ill-considered platting. We have a preponderance of landowners who seek technical advice on only two points when subdividing their land; (1) How can I

get the greatest number of lots per acre? and (2) What is the maximum number of cross streets permissible for creating corner lots?

The thoroughfare plan and subdivision control would seem to be the basis of supervised regional expansion.

G. H. HERROLD, M. Am. Soc. C.E,
Managing Director and Engineer,
The City Planning Board

St. Paul, Minn.
January 5, 1930

Westchester County Parks Another Sound Investment

DEAR SIR: The importance and desirability of comprehensive park systems in all metropolitan districts are agreed upon not only by city planners and engineers but the general public from which comes the increasing demand for recreational opportunities and facilities.

The practical working out of plans to meet these needs inevitably hinges upon the economic aspects. The Cleveland Metropolitan Park System, described by Mr. Stinchcomb in the November CIVIL ENGINEERING, is another contribution to the evidence that a well considered park program adjusted to the needs of a municipality or a region, and under competent administration and engineering, is a sound investment of public funds.

In its most important essentials, the experience developed by the Cleveland system parallels that of Westchester County. Active operations on the development of the Westchester County system were started in 1923. The figures in the following summary of the balance sheet have been widely published and studied.

The total assessed valuation of taxable property in the county in 1923 was \$788,029,096. This was the accumulated total of taxable wealth in the 240 years since the county was established in 1683. At the end of 1929 this total was \$1,644,114,324, a gain of \$856,085,228 in six years, due in a large measure to the park program. Entirely apart from the unprecedented increment in tax revenue, the development of the park system had built up a direct income of \$1,583,632 for the year 1929 from golf courses, beaches, swimming pools, concessions, and amusement park features. The total operation and maintenance expense for the same period was \$1,544,208, affording a surplus of \$39,424 for the county treasury.

On the Cleveland Metropolitan Park program the financing limitation of 0.1 mill on the tax levy would appear to be inadequate. The establishment of parks and parkways causes an immediate rise in land values of the surrounding district. The acquisition of lands required for a comprehensively planned system should be carried through with all possible expedition to avoid the inevitably higher land prices that will result from piecemeal progress arbitrarily limited by mill fractions in the tax rate.

A bolder approach to the financing problem was made by the Westchester authorities without, however, disturbing the tax rate. In 1923, when the first park appropriations were made, the situation confronting them was that the county's borrowing capacity was 10 per cent of the total assessed valuation at the end of 1922, or \$73,300,707. The county debt was \$7,636,205. At the end of 1929, the borrowing capacity was 10 per cent of \$1,644,114,324, or \$164,411,432.40 and the county debt was about \$63,000,000. The margin between actual debt and legal debt limit of 10 per cent in 1929 was increased more than 50 per cent over that of 1923, although about \$54,000,000 in bonds had been issued for a \$60,000,000 county park program. In addition to parks, the county had taken on expanded governmental programs in all departments, notably highway construction, independent of its parkways and institutional welfare work.

For the year 1929 the tax rate for all county government purposes in Westchester County was 0.374 per cent being the second lowest of the 62 counties in the State of New York. Of this total of 3.74 mills, 1.0 mill was required for the support of the park system. This tax was required for interest and amortization on bonds.

It is the soundest kind of economy for any municipality with assured future growth to concentrate all available resources on the establishment of an adequate park system in advance of such growth. If the problem is boldly met with sound business judgment, the tax rate may be satisfactorily worked out.

JAY DOWNER, M. Am. Soc. C.E.
Chief Engineer,
Westchester County Park Commission

Bronxville, N.Y.
December 15, 1930

Segregation of Operation

DEAR SIR: Mass transportation, as defined by Mr. Lockwood in January CIVIL ENGINEERING, is so important that the business activity of a city may invariably be gaged by the adequacy of its mass transportation system. The necessity for rapid and relatively cheap transportation between different parts of a city, and from these parts to its centers of daily activity, is now more pronounced than ever, and increases with the growth of the city.

When such measures as street widening, parking restrictions, one-way streets, and segregation of traffic have been exhausted in the relief of surface mass transportation and the need for further relief becomes apparent, segregation of operation is obtained by separate levels, either elevated structures or subways. The former is the less expensive and more objectionable of the two.

An analysis will show that, due to the wasteful use of street space per passenger hauled, it would be impossible to supply sufficient street area to accommodate the number of automobiles necessary, should all traffic enter the business district of a large city by automobile. Notwithstanding this, it is the private automobile, a diffuse method of transportation, which has so hampered and interfered with street car operation, a dense method of transportation, that in St. Louis, for example, the number of people entering the business district has, in the last few years, decreased roughly as much as 25,000,000 per annum. My estimate, based on traffic checks which have been made, indicates an enormous loss in shopping value to the down-town merchant, even with the customary value of \$1.00 per person going into the district placed on them.

Where the return on the cost of construction is to be expected out of earnings, separate level types of segregation are economically unsound, for the reason that the average rider could not and would not pay the necessary toll. The question then arises as to who should finance such a project. It is my opinion that the munici-

pality should provide these separate level ways or roads by bond issues, the process being quite similar in principle to the widening of a street to obtain increased capacity for traffic. It differs only in that the form taken to obtain this additional capacity of roadway is more effective. After plans have been made to pay for the project with a bond issue, arrangements for its operation should then be made with an operating company, such as, for instance, the existing transportation company.

Mr. Lockwood's plan of municipal ownership and company operation has considerable merit. However, it presupposes that the amount now set aside for depreciation reserve, over and above the actual expenditures for renewals and replacement, plus certain state and Federal taxes saved, will be available to meet interest charges and pay an amount to the city in lieu of taxes. This is subject to criticism because, although the actual property worn out may be replaced from time to time and the security of the bond holders protected, several kinds of depreciation may not be taken care of by such a plan. This is an age of destructive invention, that is, property becomes obsolete because of great changes, so that an amount should be set aside each year to take care of obsolescence.

Experience proves that, if the electric-railway industry is to continue to function and serve the public adequately, large expenditures must be made to keep electric railways up-to-date. A bid for patronage must be made by procuring new equipment and, in order to provide for these things, an amount at least equal to that which the company is annually setting aside as a depreciation reserve should be provided for. If this is not done and the property is not kept up-to-date through proper expenditure of the depreciation reserve, the security of the bond holders will not be protected.

L. C. Datz, M. Am. Soc. C.E.
Chief Engineer,
St. Louis Public Service Company

St. Louis, Mo.
December 31, 1930

Use a Stop-Watch

Dear Sir: Mr. Holcomb is to be congratulated on the success he has achieved in stating clearly and concisely, in the October issue of Civil Engineering, the various factors which directly control the rate of operation and production of certain types of excavation and material-handling equipment. His article is a much needed contribution to the field of our engineering literature.

My only regret is that Mr. Holcomb did not extend his excellent analysis to cover the coordinated operation of the complete job assembly for this type of equipment, since the production studies which the Division of Management of the Bureau of Public Roads has conducted on nearly 200 highway grading jobs indicate that the most common cause of low power-shovel production, at least in grading work, is due to a lack of proper coordination between the operation of the shovel, the hauling, and the dump equipment. In fact, the average power-shovel grading job loses nearly 40 per cent of the total time the crew is out on the road in minor delays and interruptions, no single one as much as 15 min. in duration.

Of these losses, practically one-half are due to faulty operation or insufficient supply of the hauling equipment. Yet many well managed jobs, as well as repeated field demonstrations show that, under able management, general operation can be so coordinated with the production rate of the shovel that time losses from this source will ordinarily not exceed one-sixth of this usual average amount, or about 6 or 7 per cent of the time the crew is out on the road. Principle 12 should, therefore, be expanded to include a capable superintendent.

The practical application of output multipliers to a given job, while desirable, would seem fraught with many difficulties. General averages too often prove misleading; and the number of jobs which must be covered before an individual contractor can assemble the necessary basic data to develop his own set of coefficients from his own experience is so large that few will probably make the attempt. Furthermore, the standard on which these coefficients should be based does not seem capable of exact determination, since the rate of production on almost every job is affected to varying extents by such diverse factors as the kind and character of the material, the mechanical condition of the shovel, the skill and effort of the shovel operator, the operation of the hauling equipment, as well as hauling conditions, dump operations, and weather conditions. All of these factors interact on every job in so many ways that to determine the exact effect each has on the rate of production at any time is extremely difficult, probably impossible. Consequently, the coefficients determined by any two individuals or organizations might be far from identical.

Direct time values of each of the basic operations, as obtained by the stop-watch can, however, be used to accomplish about the same purpose as the output multipliers are intended to perform and can, moreover, be readily verified by the average superintendent. Direct time values would, therefore, seem preferable, especially in view of the fact that their more general application would encourage further use of the stop-watch, which can often be made the most valuable piece of equipment in the contractor's organization.

In this connection, attention might be called to the error, as shown by the stop-watch, involved in the customary methods of computing time required for the shovel to swing through a given angle. The mere fact that a shovel can swing 4 full revolutions in a minute does not mean that, under actual operating conditions, it can operate on a swing of 24 deg. in 1 sec. Thousands of stop-watch readings of the time required for the shovel to swing through various angles, under actual operating conditions in the field, show that the lag (or time required to accelerate and decelerate, as well as for the mechanism to function) is fairly constant for any individual operator, shovel, and set of conditions, and may be as low as 1 sec. and as high as 3 sec. To obtain the actual swing time this lag must, of course, be included. On large angles, the error involved is small, but on small ones it is substantial.

Instead of suggesting that either the engineer or the contractor invest time and money in developing output multipliers, I would rather counsel both to invest a much smaller amount in a good stop-watch, and I advise its constant use on every job.

T. Warren Allen, M. Am. Soc. C.E.
Chief, Division of Management,
Bureau of Public Roads,
U.S. Department of Agriculture

Washington, D.C.
December 17, 1930

Harmonizing Laboratory and Field

DEAR SIR: In his paper, "An Accelerated Soundness Test," Dr. Kriege gives pertinent advice to testing engineers.

We use the sodium sulfate test to some extent, but are inclined to favor direct freezing as being more nearly comparable to actual weathering conditions, although we realize that many just criticisms can be made against direct freezing as ordinarily conducted in the laboratory. It would be desirable to consider carefully the errors in manipulation and interpretation of this method as Dr. Kriege did in the case of the sodium sulfate test.

As Dr. Kriege inferred, our present information is not very complete as to the relationship between sodium sulfate soundness and actual durability of the material under field conditions. We feel that any accelerated soundness test, as now conducted, has very limited practical application to concrete durability because the resistance to disintegration may be entirely different after the aggregate has been incorporated in a cement mortar. No matter which type of accelerated test is employed, how can we definitely tell from the number of pieces or weight of disintegrated matter the time in which the material will disintegrate, to the same degree, under actual weathering conditions; or how can we establish the relationship of a given number of repetitions of such tests of the aggregate to the same degree of disintegration under actual service conditions? Then when we consider the aggregate surrounded by a cement mortar, the relationship of such tests to durability becomes even more complicated.

It is very true that the failure of an aggregate to pass an accelerated soundness test may be a real danger signal, and it is heeded wherever possible. However, we have structures built of aggregate that would fail to meet such tests, and no signs of disintegration can be found after several years of service. In some localities, it becomes a quite serious economic problem to select suitable materials; and lacking more definite information, we hesitate to condemn a material where availability is paramount, simply because the aggregate happens to fail to pass an accelerated test.

Since more thought is being given to this matter, and there is some evidence to show that mineralogical composition and other inherent properties of aggregates are closely related to the durability of concrete composed of them, it would seem quite desirable to consider carefully the inter-relationship of such characteristics to an accelerated test.

By a diligent study of climatological data, it would seem within the realms of possibility to plot, fairly accurately, the prevailing weather characteristics of certain geographical areas. Assuming that alternating moisture and dryness and freezing and thawing are the principal weathering forces inducing disintegration, in areas free from acid or alkali water, such climatological data should be helpful in formulating a more definite relationship between a laboratory test and actual field behavior.

The thought we wish to emphasize is that perhaps we are attempting to give a too wide application to a given accelerated test. It would seem more logical to attempt to establish a relationship between accelerated laboratory tests and field conditions after we have made a more careful study of the inherent characteristics of aggregates; a more detailed study of temperature, moisture, freezing, and thawing ranges within certain localities; and a more careful consideration of the actual conditions to which the aggregates or concrete will be subjected within that area. For example, the sodium sulfate test might have great practical value in areas which are entirely free from frost and where the aggregate or concrete is subjected to the extreme effects of changing moisture and dryness and the absorption and crystallization of soluble material. In other areas, an accelerated freezing and thawing test might be more applicable.

We realize the magnitude of such a consideration as suggested, but when confronted with such an intangible subject and the vital importance of predicting the probable life of our structures, we offer such comments for what they may be worth. It is our opinion that a test for the durability of concrete is just as important or even more important than one for the soundness of coarse aggregate, and that studies of the two tests should progress hand in hand. We believe that future studies will eventually prove that the life of concrete is very largely dependent upon the character, shape, and arrangement of the voids remaining after set, assuming that the materials entering into the concrete are of satisfactory quality, and that the purely physical phenomena attendant upon the elimination of excess water and the resulting shrinkage during and immediately following the setting of the cement determine the relative durability of the resultant product.

It is noted that the Materials Committees of the National Research Council and of the American Association of State Highway Officials are becoming very much interested in the problem of determining the durability of concrete. Prof. C. H. Scholer of the Kansas State Agricultural College has been conducting a very extensive research along this line, progress reports of which have been currently appearing in publications of the Research Council and of the American Society for Testing Materials. These reports should be of great interest and value to any one engaged in research along this general line.

F. V. REAGEL
Engineer of Materials,
State Highway Department

Jefferson City, Mo.
December 22, 1930

Standardizing Data for Filtering Materials

SIR: The papers on filtering materials for water and sewage works, as presented in the November issue, are noteworthy contributions.

A standard test by which the durability of material for sewage trickling filters can be determined is very desirable. The work of the committee indicates that such a test is almost at hand. The committee should push its work to the end to establish such a test and submit a final report at that time. A valuable piece of work will have been accomplished if the sodium sulfate soundness test is placed upon a recognized basis.

There seems to be no logical reason for holding the conclusions as to this test until questions of filter operation are thrashed out. The durability of the filter material having been determined, successful filter operation is dependent upon so many conditions not related to that particular subject, that the two might well be separate considerations.

The results of the cooperative tests, using the sodium sulfate soundness test as outlined by the committee, are very interesting. The consistency of the "O.K.

results" of a few laboratories is quite noteworthy. The data presented in Tables 8 and 9 indicate that the results of the proposed test are logical and that, while the test need not be carried too far, the number of samples tested should not be too limited.

The first essentials of trickling-filter material are durability and sufficient, but not excessive, roughness. Cleanliness and size are subject to control. The quality of the material having been proven, it is the task of the engineer to see that the material as placed in the filter is in proper condition and of satisfactory size. The expense involved, rather than the quality of the medium, generally determines the choice of a suitable material.

Range of size of filter material and its depth is the next concern. The trickling filter is a wonderful unit of sewage treatment because of its ability to turn out an effluent of reasonably uniform quality, if not overloaded, when treating sewage having varying characteristics. Trickling filters of various depths and sizes of material, located in widely separated communities with considerable difference of average temperature conditions, have been successfully operated.

Selection of the size and depth of filter material should be made only after a careful study of the results of operation of these various plants. Unit filter-loading data without notation of all conditions are unsatisfactory. Experimental filter operation probably furnishes the most reliable data as to selection of material of proper size and determination of filter depth.

Standardization of the essential data pertaining to trickling-filter construction and operation is a difficult matter and can proceed only to a limited extent. Satisfactory design will utilize such data to this point and, beyond that, local conditions in connection with similar experience elsewhere will determine the size and depth of the filter material.

ROY S. LANPHEAR
Supervising Chemist, Sewer Department, City of Worcester

Worcester, Mass.
December 26, 1930

Public Opinion and Water Supply

TO THE EDITOR: Probably one of the most difficult features connected with the matter of water supply for large cities is the outlining of the necessary improvements far enough in advance of their actual need to secure their accomplishment at the proper time. It is necessary in most cases to secure funds for capital investment by bond issues. This requires careful preparation of the program and its presentation to the people in such a way that the project is thoroughly understood. In his paper in the January issue, Mr. Wall describes the plan followed at St. Louis, which was undoubtedly very successful. The responsibility for keeping the plans for enlargement well ahead of the actual development falls upon the operating personnel, which means that it is vital for cities to have high-class men in charge of their water departments.

Such items as the development in pumping machinery, the advent of complete metering of supplies, and the modern methods employed in maintaining and operating distribution systems, have made of modern water supply an outstanding engineering accomplishment. The modern, steam-driven, centrifugal pumps—pigmies in size, compared to the large, triple-expansion, direct-acting units used extensively 20 years ago—are doing the same work and doing it more cheaply on the basis of present higher costs. The advent of meters into the modern water system has held the consumption of water to a reasonable amount, without curtailing the proper use by the consumers. The modern "distribution department" in our larger cities is usually an efficient and effective organization, prepared to meet any emergency both with necessary supplies and man power.

While the advancement in the art of supplying water to cities has been going on, the engineering profession has also made it possible to improve the quality of the water supplies themselves, through the development of the modern methods of sewage purification. The development in both the purification of water and the disposal of sewage, together with the efficient work of our government and state health officials, has caused the creation of a public sanitary conscience, which is getting stronger every year. Public opinion will no longer countenance an impure or questionable water supply and, generally speaking, will not expect to discharge its waste into water courses, where such action is prejudicial to the health or welfare of other cities or individuals. Engineers and others engaged in sanitary work may look with pride upon what has been accomplished, but there is still greater efficiency and effectiveness possible, and the success achieved should spur all of us on to greater accomplishment.

N. T. VEATCH, JR., M. Am. Soc. C.E.
Black and Veatch, Consulting Engineers

Kansas City, Mo.
January 8, 1931

Limitations of Sodium Sulfate Test

DEAR SIR: The excellent paper by Dr. Herbert F. Kriege, entitled "An Accelerated Soundness Test," in the November issue of CIVIL ENGINEERING, is a timely contribution to the science of materials testing. Dr. Kriege has pointed out very clearly the variables to which the sodium sulfate test is likely to be subjected, and I have no doubt that, if his suggestions are followed, it will be a more useful testing tool than as at present performed.

With regard to the testing of fine aggregate, many natural sands vary in their soundness as between the different sieve sizes and, therefore, false results might be obtained if the sodium sulfate test is performed on only one of these sizes. There is doubt in my mind as to the advisability of considering the sodium sulfate test as anything more than a warning signal regarding the soundness of rock or other aggregates, especially when these aggregates are to be used in concrete.

There is also doubt as to the wisdom of specifying the same test limits in the sodium sulfate test, irrespective of the exposure conditions, which have a wide range throughout the United States. I do not believe that all rocks which fail in the sodium sulfate test are unsound in the sense that they would cause trouble when used as a concrete aggregate.

Dr. Kriege's paper affords a most excellent starting point in a comprehensive investigation of the sodium sulfate test which should be widely undertaken under the direction of some single agency.

A. T. GOLDBECK, Assoc. M. Am. Soc. C.E.
Director, Bureau of Engineering

Washington, D.C.
December 19, 1930

Welding Kinks for Hydraulic Dredge Pipe

DEAR SIR: In connection with Professor McKibben's interesting and instructive article, "Arc Welding on Steel Buildings," in the October issue, it might be of interest to point out the progress made in the electric welding of pipe, particularly that used on hydraulic dredge pipe lines.

Pipe for this purpose was, until a few years ago, riveted with the attendant trouble of leaky rivets. Often it was only partially worn before requiring re-riveting. But this was not always satisfactory because of the metal being worn away around the old rivet-heads.

Several types of welded joints were tried and found more or less unsatisfactory. The type most commonly used at the present time is the plain lap joint, welded inside and out, which has proved very satisfactory. Hydraulic dredge shore pipe is usually made in 15-ft. lengths of $^3/_{16}$-in. to $^1/_4$-in. plate, composed of 0.30 per cent to 0.40 per cent carbon steel. The pontoon pipe is usually made up in 50-ft. to 100-ft. lengths of $^3/_8$-in. to $^3/_4$-in. plate and with the same carbon content. The size of pipe most commonly used varies between 18-in. and 30-in. diameter. This pipe is welded by automatic machines or manually, or both. The discharge pressures on the present-day, high-powered hydraulic dredges are quite often around 80 to 100 lb. per sq. in. During surges in the pipe line, caused by the momentary plugging of the suction pipe to the dredge pump, the pressures may vary almost instantaneously from zero to 150 lb. per sq. in. or more.

It is customary with the larger dredges to have one, and sometimes two, portable welding sets which may be moved to any location on the job where welding is required. A few of the uses to which a portable welding machine can be put are: welding patches on pipes having holes worn in them by the material transported; cutting off pipes or welding pipe sections together; welding flanges to pipe; welding up seams or burst pipes; building up impeller and cutter shafts worn down at bearings; building up worn sections on impellers; and in the main dredge pumps.

OLE P. ERICKSON, M. Am. Soc. C.E.
Engineer, Great Lakes Dredge and Dock Company

Chicago, Ill.
December 16, 1930

Pilot Channel Experience

EDITOR: Major Fox's paper on the Brazos River channel change, in the January issue of CIVIL ENGINEERING, brings up an interesting problem on the question of diversion channels on rivers.

At a point on the Trinity River about 100 miles below Dallas, Henderson County Levee Improvement District No. 3 was constructed in 1926–1927. The project comprises the reclamation of 15,000 acres of river-bottom lands by means of levees, drainage ditches, and channel straightening. The total yardage involved in this project on embankment and in excavation is 4,800,000 cu. yd., and the soil is a stiff, black clay, with some spots of sandy loam appearing at intervals. A part of the plan of reclamation consisted of the abandonment of about 8 miles of the old channel of the Trinity River through the cutting of a new diversion channel 4.6 miles in length, the diversion channel being thrown to one side of the valley in order to use the hills on this side as a part of the levee system. In constructing the diversion channel, there was excavated what we term locally a pilot channel, having a cross section of from 400 to 500 sq. ft., this section being as small as could be excavated with the drag-line bucket.

Our experience on this type of reclamation led us to believe that such a channel would enlarge itself in a short time to the full cross section necessary to accommodate the normal flow and bank-full stages of the river.

As shown by the diagram, this plan worked out as anticipated, and the sections enlarged themselves from an area of about 450 sq. ft., at the time water was turned into the pilot channel, to 3,500 sq. ft. in 25 months' time. The channels excavated in this manner along the Trinity River and other streams in the vicinity have kept a good alignment to date, and no troubles are anticipated from pockets or bends developing in such channels.

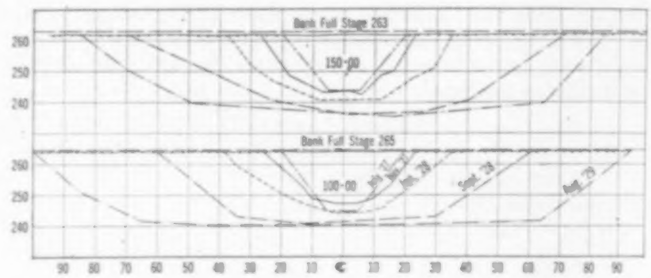


DIAGRAM OF THE TRINITY RIVER DIVERSION CHANNEL, DALLAS

About 100 miles northeast of Dallas on the North Sulphur River is a project known as Fannin-Lamar-Delta County Levee Improvement District No. 3, where there has been constructed a pilot channel 18 miles in length. This channel enlarged itself through erosion

PILOT CHANNEL TRINITY RIVER PROJECT, BELOW DALLAS

SAME CHANNEL SIX MONTHS LATER

by an average of 97.6 per cent in one year. The soil is a stiff black clay underlain with stiff yellow clay, and the erosion has been uniform with no tendency toward the development of bends.

On the Trinity River project at Dallas, our experience has been the same in the enlargement of the pilot channels on a length of approximately 5 miles of completed diversion channel, which has been placed in use, there being about 15 additional miles of channel which has not been in use a sufficient length of time to develop erosion.

E. N. NOYES, M. Am. Soc. C.E.
Myers, Noyes and Forrest, Consulting Engineers

Dallas, Tex.
January 10, 1931

Model Tests Verify Calculations

DEAR SIR: The article by Mr. Bull, entitled "New Method of Mechanical Analysis for Trusses," in the December issue of CIVIL ENGINEERING, has placed engineers under obligation for the very ingenious and timesaving method that he has devised.

Continuous structures, reinforced concrete construction, and rigid joints in steel construction together make the problem of stress analysis no longer one of simple mechanics. There are continuity and rigidity in the frames; so there is a growing need for simple methods of mechanical stress analysis.

The use of models for determining stresses in hyperstatic structures by measuring deformations, first developed by Prof. George E. Beggs, about 1925, has progressed rapidly and has made very easy the solution of problems which, if undertaken by rigid mathematical analysis, would often be very tedious and almost impracticable in many cases. The making of the models with brass rods, as suggested by Mr. Bull, is quite a simple process, and it is surprising how closely the results check with those made by calculations, even when the results are read on a scale of $^1/_{100}$ in. with an ordinary magnifying glass. I have thus checked the stresses in a rigid frame within 5 per cent of those obtained by calculation.

As a suggestion, perhaps Mr. Bull will take the time to write another article giving further information as to the use of brass-rod models for diverse problems. I am sure it would be both interesting and valuable.

EUGENE W. STERN, M. Am. Soc. C.E.
Consulting Engineer

New York, N.Y.
December 27, 1930

Limitation of Mechanical Analysis

SIR: The method of mechanical analysis devised by Mr. Bull and described in the December issue of CIVIL ENGINEERING, is ingenious, but its value to the structural engineer is questionable. It is not adapted to the finding of internal stresses, axial or bending, but is fundamentally a mechanical solution for the determination of influence lines for redundant reactions. These influence lines can be determined quite simply and accurately by means of the graphical Williot diagrams or the algebraic "internal work" method, regardless of the number of spans or the system of truss cancellation.

Trusses with redundant internal members, particularly double intersection members, would be rather difficult to analyze by this mechanical method. It is evident from the illustrations of the paper that, if any panel were to contain double diagonals, there would be no room for another "spring" unit for the extra member. The application of this method to the Hudson River Bridge towers, in which there are many redundant members, appears to be out of the question. It is true that mathematical computations on such structural units may become involved, but they present no serious difficulties to experts engaged on work of that magnitude. If a "model study" of such a unit or a Bayonne arch is necessary to supplement mathematical analyses, it is better to make the model a physical reproduction of the original in so far as it is possible. That, we understand, was done in the cases referred to.

The structural engineer is not so much interested in obtaining mechanical checks on axial stresses. He is more interested in finding out the effect of making the truss spans "space frames" in which practically all units are subject to end restraints and secondary bending stresses, due to the fact that they are riveted instead of being mounted on the frictionless pins assumed in analysis for axial stresses. Because of fairly recent developments in structural analysis, these secondary effects are quite simply determined by algebraic methods.

The true function of any mechanical-model analysis is to supplement, but not supplant, mathematical computations. Moreover, the study of models is warranted only in cases of unusual structural units where uncertainty exists as to the manner of load travel. There is no uncertainty about the mathematical aspects of the laws of statics or the laws of elastic deformations, upon which all structural analysis is based.

J. A. L. WADDELL, M. Am. Soc. C.E.
HAROLD E. WESSMAN, Assoc. M. Am. Soc. C.E.
Waddell and Hardesty, Consulting Engineers

New York, N.Y.
December 22, 1930

Comparative Model Tests Desirable

DEAR SIR: In so far as the thesis on "New Method of Mechanical Analysis for Trusses," by Anders H. Bull, in the November issue, emphasizes the utility of checking theoretical analysis of stresses by tests with models, it will have the unqualified endorsement of all designing engineers. But the theoretical determination of stresses remains, nevertheless, the foundation for any designer.

Mr. Bull's contrivance for measuring the axial stresses in members leads, obviously, to more accurate results than the usual method of measuring in models the elastic changes in length, either in tension or compression, in frames where all stresses are axial; but it cannot be applied to frames in which the members are subject to bending stresses and where these bending stresses are relied on for distributing the load effects and carrying them to the bearings as, for instance, in the Vierendeel system of trussing.

The first structure of this kind in this country was the Kinzua Viaduct, on a coal branch of the Erie Railroad, built in 1901 on plans by C. R. Grimm. A series of high-trestle towers carries the railroad over a deep ravine. The trestle towers have no diagonals but are braced through large fillets in the corners of the posts and horizontal braces. The claim made for this form of bracing was that it resulted in a stiffer and more economi-

cal tower. Mr. Grimm relied entirely on theoretical analysis for the stresses in the towers, which were a novelty at the time.

It would be interesting and informing if two models were made of one such tower—one model with diagonals lengthwise and crosswise in the usual form of tower design, and another model with bracing on the Vierendeel system, as designed by Mr. Grimm. The axial stresses from longitudinal and lateral forces in towers in the first model should be measured by the contrivance of Mr. Bull.

The second model should be of celluloid, which would permit measuring, to a certain degree, the bending stresses in the members. Comparison of results in both models, including deflections, would be most instructive. We have nothing of the kind now.

Some one of our engineering schools should make such tests in its testing laboratory. Its importance may be gaged from the fact that the bracing of the structural framework of our skyscrapers is designed on the Vierendeel theory or modification of it, and that factual knowledge from tests is not yet established. Reliance is here entirely on theory, but for true progress in designing we should have confirming tests with models, to which Mr. Bull's method would be only partially applicable.

GUSTAV LINDENTHAL, Hon. M. Am. Soc. C.E.
President and Chief Engineer,
North River Bridge Company

Jersey City, N.J.
December 24, 1930

Clearing House for Wire Rope Data

DEAR SIR: In connection with B. R. Leffler's paper, "Heavy Duty Wire Ropes and Sheaves," I should like to comment briefly on the work which a special research committee of the American Society of Mechanical Engineers is doing in an attempt to develop a satisfactory method for determining the life of wire rope in service.

Two years ago the Main Research Committee of the Society undertook to investigate the need for research on wire rope with the cooperation of Engineering Foundation. Several large conferences of engineers, representative of the manufacturers and the many fields of use of wire rope, both here and abroad, were held to discuss the subject. These conferences served to emphasize the pressing need that exists for a satisfactory method of determining the useful life of wire rope in service. A cooperative research committee was accordingly organized by the Society among engineering executives from the various large fields of wire rope use to prosecute a research program on the problem.

In approaching the problem, the committee is following the theory of David L. Lindquist, Chief Engineer, Otis Elevator Company, that a definite relation exists between the wear and number of broken wires in a rope and its remaining useful life; and that this relation could be established through the collection of a large amount of data on discarded rope and the correlation of these data with the breaking strength of samples of the rope taken at the points of inspection. Service data sheets have accordingly been prepared, and the committee is undertaking to obtain the cooperation of wire rope users in the collection of the desired data. Negotiations are now being carried on with a suitable testing laboratory to undertake the breaking tests of the samples of rope on which service data are obtained.

I may say that this study is being confined at present to hoisting ropes, as conditions in this field of use are fairly well controlled and offer the most promising point of beginning. Large quantities of wire rope are used, of course, by civil engineers on derricks and hoists of various kinds. I trust, therefore, that members of the American Society of Civil Engineers will cooperate in the collection of service data. Communications may be addressed to our committee at 29 West 39th Street, New York, N.Y.

W. H. FULWEILER, Assoc. M. Am. Soc. C.E.
Temporary Chairman,
Special Research Committee on Wire Rope
American Society of Mechanical Engineers

New York, N.Y.
December 17, 1930

Control Surveys Essential Before Topographic Mapping

TO THE EDITOR: The modernization of triangulation practice and the resulting increased production of control surveys of a high order, discussed in the December number of CIVIL ENGINEERING by Maj. William Bowie, is a subject of primary interest to the Geological Survey since the results of the control surveys executed by the U.S. Coast and Geodetic Survey form the basis for third-order control required by the Geological Survey in connection with, and as a part of, its program of topographic mapping.

The United States Geological Survey, through its Topographic Branch, has for about a half century been engaged in making a topographic map of the United States in the form of atlas sheet units bounded by meridians of longitude and parallels of latitude. The work has been in widely scattered areas selected because of their scientific, economic, or engineering importance as funds have been made available for carrying on this work.

Each atlas sheet or quadrangle map is a separate unit having its own origin of projection. The work of mapping is by plane-table methods in which horizontal measurements are determined either by stadia or graphical triangulation. Since third-order horizontal control requires a minimum closure of 1:5,000 in distance or a triangle closure of 5 sec. of arc, third-order control is of sufficient accuracy for holding plane-table surveys in position for a single quadrangle map, because the maximum allowable errors in the control are too small to be shown graphically on the mapping scales in use.

Geodetic positions resulting from the control surveys, in effect, establish the location of the meridians and parallels which are the boundaries of quadrangles and insure relative locations of the features shown on the map within plotting accuracy. Control surveys checking or closing back upon themselves show only uncompensated or accidental errors in closures; and the continued expansion (looping) of third-order control, particularly transit traverse control, without checking on surveys of a higher order, results in an accumulation of error in latitude and longitude known as swing. It is apparent that, in a country embracing more than 3,000,000 square miles, the satisfactory joining of quadrangle maps controlled by third-order surveys is contingent on such geodetic control being adjusted to surveys of a higher order.

The greater part of the topographic mapping that the U.S. Geological Survey does is in cooperation with the states so that the need for basic control is in many

widely separated areas. Control surveys of the first and second order should be executed well in advance of any demands for topographic mapping. Past experience has shown that the topographic mapping of areas, which have suddenly acquired great economic or engineering importance to the State or Nation, has had to be postponed for a year because such basic control was not ready. Through close cooperation between these two organizations of the Federal Government, the Coast and Geodetic Survey is expanding its control net in areas where it will be of the greatest service to the Geological Survey.

The lack of horizontal control surveys of the first or second order, in advance of topographic mapping, results in accumulations of error in horizontal position of magnitudes sufficient to cause serious difficulty in the proper joining of quadrangle maps. Such errors are known to exist at the present time in a number of localities and eventually will cause additional expenditures for the readjustment of third-order control and engraved quadrangle maps.

While Major Bowie's paper and this discusson have been devoted to horizontal control surveys, practically the same situation exists in regard to levels or vertical control. The value of executing control surveys of a high order of accuracy well in advance of immediate needs cannot, in my opinion, be too strongly emphasized.

J. G. Staack, M. Am. Soc. C.E.
Chief Topographic Engineer, U.S. Geological Survey

Washington, D.C.
December 30, 1930

Progress in Surveying Technic

To the Editor: Major Bowie's article, in the December issue, on "Modernizing Triangulation Practice" is an extremely interesting one. Although the article really needs no elaboration, there occur to me one or two rather significant points which may be of further interest.

In pioneer days in the Coast and Geodetic Survey, certain very high standards were set for the precision of its triangulation, such, for instance, as the one-second triangle closure or the extremely small discrepancy allowed between bases, as mentioned by Major Bowie. These standards were difficult to attain and originally required the use of the now-obsolete cumbersome methods and instruments mentioned. Then, as the work progressed, in directing its efforts the bureau really had two distinct courses open: it could have striven for still higher accuracy, or to attain the same accuracy with easier and cheaper methods and with far greater rapidity. It chose, one might say, the latter course. Present-day leadership of the Coast and Geodetic Survey among the geodetic survey organizations of the world is indicative of its success, and Major Bowie's article shows how well it has accomplished its purpose.

But its achievement in this phase of the work is not all. Equally as important and commendable as the Survey's degree of success in its chosen purpose, as described by Major Bowie, is the very choice of the purpose itself. This is especially noteworthy in the light of present-day engineering demands for the results of geodetic triangulation, which are being splendidly fulfilled by the accelerated methods—and are, incidentally, serving to dispel the mystery enshrouding geodetic surveying, as Major Bowie has pointed out. In fact, no higher degree of precision than that maintained by the accelerated methods is ever likely to be demanded, even for the scientific uses of triangulation (concerning which, by the way, considerable mystery still prevails for the average engineer).

Another point not particularly emphasized in the paper is the brief time interval during which this modernizing has been accomplished; and, of course, the extent to which Major Bowie is personally responsible for the new methods is not mentioned. Nearly all of the improvements cited have been made during Major Bowie's administration as Chief of the Division of Geodesy. For some of these innovations he is directly responsible, and for nearly all of them he is indirectly responsible. Not to detract at all from the ingenuity of Mr. Bilby in designing his steel towers, or of Mr. Parkhurst in constructing the new theodolite, or of any of the others to whom credit is justly due, it is certain, nevertheless, that behind all these noteworthy accomplishments is Major Bowie's own persistent effort and the progressive and cooperative spirit which has permeated the Division of Geodesy of the Coast and Geodetic Survey during all of his period of faithful service.

It is hoped that Major Bowie will continue writing both scientific and popular articles concerning the various phases of geodetic work.

Earl Church
Assistant Professor of Civil Engineering, Syracuse University

Syracuse, N.Y.
January 5, 1931

In Defense of Old Geodesists

Dear Sir: In the article entitled, "Modernizing Triangulation Practice," by William Bowie, which appeared in the December issue of Civil Engineering, there is depicted in a clear manner the evolution of first-order triangulation practice leading to the present high standard of efficiency attained in that branch of geodetic engineering.

The first-order control survey forms the skeleton framework upon which is based, or will be based in the near future, all properly coordinated topographic and cadastral surveys of Federal, state, and municipal organizations, as well as important construction projects of more private nature.

The author shows the great increase in the number of triangulation stations occupied in a single season over the number occupied during a field season prior to 1902. It should be noted to the credit of these older observers, however, that their patience and fortitude were such that although it required weeks—and in some cases a month or two—to obtain sufficient heliograph observations, the accuracy which they secured by the expedient of this large number of observations is comparable to that now attained in a single night using the improved instruments and methods described by the author. This fidelity on the part of the coast and geodetic observers during the latter half of the nineteenth century makes it now possible by reoccupation to detect earth movements which may have occurred during the interval.

Development of the Bilby steel tower has been a great boon to the geodetic engineer but doubtless something of a disappointment to the owners of land

on which the stations are located. I recall that it was not uncommon to find that barns or other buildings had been constructed from the lumber of abandoned high wooden signals.

As stated in the paper, 160 pointings on signal lamps are required at the normal station of a quadrilateral. With the use of the 12-in. theodolite, a "pointing per minute" was considered to be a good average observing speed. The new 9-in. theodolite designed by D. L. Parkhurst makes it possible to more than double this rate, due in a large measure to the elimination of the third micrometer with its readings to the amount of $33^1/_3$ per cent, as well as to greater ease of manipulation. It is hoped that instrument-makers in this country will appreciate the growing demand for first-order micrometer direction theodolites on the part of municipal and other organizations engaged on important construction works, and will be in a position to supply this demand at less than prohibitive costs.

In presenting his paper, Major Bowie has drawn upon the wealth of information and experience available to him after 35 years in the service of the U.S. Coast and Goedetic Survey. We who have had the privilege of serving in the Division of Geodesy fully appreciate the great extent to which the author has personally contributed to the rapid progress described in his paper on "Modernizing Triangulation Practice."

FLOYD W. HOUGH, Assoc. M. Am. Soc. C.E.
Geodetic Engineer, Metropolitan Water District of Southern California

Beaumont, Calif.
December 23, 1930

Triangulation Has Hidden Value

THE EDITOR: Engineers as a class are familiar with, and largely responsible for, mass production in industry; but it is something of a surprise to those who are not closely associated with the more scientific branches of the profession to find mass production therein. Mr. Bowie's paper, in the December issue of CIVIL ENGINEERING, interestingly sets forth the progress and development in the geodetic work of the Coast and Geodetic Survey during the last 30 years. This development has been in response to the increased demand for the framework, first-order triangulation, on which all maps covering large areas must be based. The structural steel of the skyscraper is soon covered and forgotten, but without it the building could not stand. So triangulation, that very essential control of accurate maps, is little known by engineers not engaged in mapping large areas.

There is one point that needs to be brought before the profession at this time. Many costly airplane surveys are in progress which can never yield their full inherent benefits because of the lack of accurate ground control. The American public has been educated to, and is convinced of, the need for accurate maps, and it is rather well sold on the use of the airplane in making these maps. It needs to know that control is necessary and that control must come first if it is to receive dollar-for-dollar value for funds expended in such work.

When reading about triangulation it is of interest to consider the meaning of a closure of 1 sec. per triangle. If it is assumed that all error is in one angle, this closure means that at the end of a 100-mile line, a not uncommon length, the line of sight is 2.64 ft. in error. However, at the perimeter of a 9-in. theodolite plate, it is only two hundred-thousandths of an inch. It is thus seen that, to secure accuracy and efficiency, a careful balance must be obtained between stability of material, portability, and accuracy of construction on the part of the instrument and organization, and method of observation on the part of the field work. A close cooperation between instrument maker and field engineer is clearly necessary.

The developments described by Mr. Bowie have made the United States Coast and Geodetic Survey the most efficient organization of its kind in the world. It deserves the support of all engineers, for engineers will be the first to benefit from the extension of geodetic control to all parts of the country.

C. M. CADE, M. Am. Soc. C.E.
Associate Professor of Civil Engineering, Michigan State College

East Lansing, Mich.
December 20, 1930

Modernizing the Use of Triangulation Data

DEAR SIR: A corollary of the article on "Modernizing Triangulation Practice," by William Bowie, in the December issue of CIVIL ENGINEERING, would be "Modernizing the Use of Triangulation Data." The general use of this important information has not kept step with the very rapid spread of the triangulation net shown by Major Bowie, excepting only in the field of topographic mapping and, to a limited extent, in making precise city surveys. An almost unlimited field exists, if we are to verify the geographic position of the land surveys and to control all large-scale topographic mapping. All authorities concede that the geographic positions which are derived by triangulation establish the standard of precision to which all other surveying—topographic, cadastral, and aerial—may and should come for verification, adjustment, and comparison.

Ordinarily, only the principal land boundaries are shown upon the standard topographic maps, as the uncertainties of the geographic position of the cadastral surveys, and the difficulties and time required in the search for, and identification of, the monuments add altogether too much to the work of the topographer. This can best be overcome by those engaged in the cadastral surveys, if triangulation stations are near enough at hand to correlate the land boundaries to that control. It is doubtful if those not directly concerned realize the uniform accuracy obtainable from triangulation. This was impossible in the early topographic and cadastral surveys when the geographic positions were derived largely from astronomical observations, or by calculation from distant points—themselves more or less uncertain in location.

The scope of the triangulation now available and the precision of the results shown by the author are an outstanding achievement and, when carried to second-order stations established at intervals of 5 to 12 miles, should be employed to verify the geographic position of the land surveys. The longer lines of the triangulation cannot ordinarily be utilized in land surveying work, excepting to make the occasional ties; and if many points are to be connected it is better to put in stations at frequent intervals, but the point is reached where the triangulation becomes unnecessarily expensive and traverse methods are more suitable. Such connections,

coupled with necessary retracements where unallowable discrepancies are discovered, afford the only practical general plan for adjusting the land surveys to the triangulation.

Small discrepancies in the record of the land surveys can be distributed by the usual methods of balancing closures, where the purpose is to compute the geographic positions. This will have no effect upon the boundaries themselves, as by law the evidences of the monuments are given preference over the record of the directions and lengths of lines, and their geographic position.

Now that the country-wide triangulation is brought closer to hand, connections to it should be made on all important cadastral surveys, and a concerted interest in doing so will be a very forward step.

ARTHUR D. KIDDER, M. Am. Soc. C.E.
United States General Land Office

Washington, D.C.
January 3, 1931

Memory Knowledge Versus Straight Thinking

DEAR SIR: I am in general agreement with all of President Wickenden's suggestions contained in his paper, "Professional Status of the Engineer," in the October number, although I foresee considerable difficulty in carrying them out.

A sharp line should be drawn between two types of "knowledge," the one which may be labeled memory knowledge, and the other, the habit of analysis supported by a sound understanding of the fundamentals of science underlying engineering. Of the two varieties of knowledge the second, namely, the habit of clear, straight thinking, is much the more important, as well as the more rare.

Unless the tests upon which certification is based cover this second kind of knowledge, I feel sure that we will be no better off than before.

COMFORT A. ADAMS, M. Am. Soc. C.E.
Lawrence Professor of Engineering, Harvard Engineering School

Cambridge, Mass.
December 6, 1930

A Staggering Volume of Scientific Knowledge

TO THE EDITOR: Alfred D. Flinn, in his interesting and suggestive paper entitled "Research Advances Civil Engineering," published in your issue for October, propounds a knotty problem in the first paragraph when he asks, "How can all existing knowledge that should be utilized on a given project be quickly put into the hands of the man on the job, so that he can be assured that he is doing his work with the benefit of all the known facts which bear on his problem?" In the next sentence Mr. Flinn cites the inaccessibility of knowledge as our greatest cause of waste.

The day has, of course, gone by when any one can hope to take all knowledge for his province, and I fear the day has also gone when one may hope to have the benefit of all the known facts which bear upon any complex problem. In our own laboratory, which is primarily concerned with industrial research along chemical lines, the best that we have been able to do is to evolve a type of group organization in which each member of an individual group is expected to contribute his quota of information to the broader field in which the group is working. Conferences between group heads thus bring together the integrated knowledge of the staff for the consideration of our larger problems. To put it in another way, the time has come when research has almost ceased to be a function of the individual because the accumulated knowledge required for its successful prosecution can usually be brought to bear only by focusing the contributions of several or many minds.

I know of no better means of making knowledge accessible than through bibliographies and abstract journals, provided these are supplemented by a continuous flood of monographs. This is the system adopted by the American Chemical Society, but indispensable though it has proved to be, the material offered is depressing in its magnitude and demonstrates the futility of hoping that any single individual can grasp more than a restricted portion of the field of any modern science.

ARTHUR D. LITTLE
Arthur D. Little, Inc., Chemists, Engineers, Managers

Cambridge, Mass.
December 27, 1930

Practical Assimilation of Engineering Knowledge

DEAR SIR: In Dr. Flinn's most interesting article on "Research Advances Civil Engineering," in the October issue, he asks how existing knowledge of a given subject can be made readily available to the "man on the job."

This depends somewhat on where the man happens to be located. If he is in a large city, the public and technical libraries will be at his command. If he is far from civilization, he will have to depend on correspondence. In any event, an engineer should be a member of the engineering society which covers his field of activity, for in its papers he will find the most recent developments in his particular line. In addition, he should subscribe to such technical and trade journals as pertain to his subject, and thus be furnished with another source of latest practice. Finally, he should acquire a well selected library of his own as rapidly as his resources will permit.

Although possession of these means of information is important, that in itself is not sufficient, for it is only by careful perusal that the mind has something to work on—the ideas and experience of others—and this is essential for right thought and action. Then, too, the man on the job should utilize the experience of those about him—whether engineers, contractors, or salesmen—who have had that practical experience not often found in books, but which may be of utmost value.

After securing all this knowledge from various sources, the engineer, by careful thought and study, should be able to give due weight to each factor bearing on his problem, and thus arrive at a correct solution.

PHILIP W. HENRY, M. Am. Soc. C.E.
Consulting Engineer

New York, N.Y.
December 30, 1930

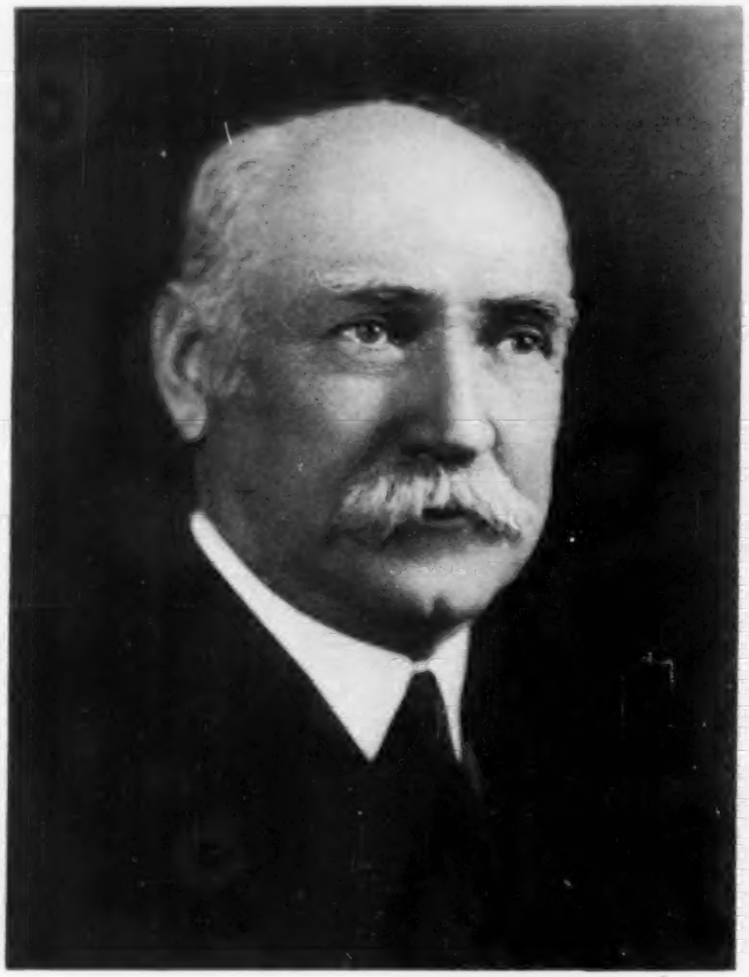
SOCIETY AFFAIRS

Official and Semi-Official

Francis Lee Stuart, Sixty-Second President

Born in the South, Francis Lee Stuart received his early education at Emerson Institute, Washington, D.C., and in 1884 started his engineering apprenticeship in the office of Col. James F. Randolph, Consulting Engineer of the Baltimore and Ohio Railroad. Here he began an active experience with this and other eastern and southern railroads in the engineering, maintenance, and operating departments, deliberately planned to acquire experience regardless of salary. Successively, he occupied such positions as resident engineer on construction, engineer of maintenance of way, trainmaster, and operating superintendent.

After 13 years of railroad and coal mine engineering, he felt a keen desire to have a complete change from it. Surveys of the Nicaragua Canal were proposed and he accepted the first appointment offered, that of instrumentman. Advancing successively to Chief of Party on levels and triangulation along the Rio San Juan, he was finally put in charge of the canal surveys on the eastern side of Nicaragua, including a hydrographic and triangulation survey of Lake Nicaragua. Tropical fever forced his return to the United States on two occasions. This experience, where every man was forced to depend on his own resources to get results, did much to develop his aggressiveness in thought and action.



Francis Lee Stuart
President, American Society of Civil Engineers

Reentering the service of the Baltimore and Ohio Railroad, he was largely responsible for efforts to get lower trunk line grades than the 0.3 per cent then in use, and many economies have resulted from his relocations on 0.1 and 0.15 per cent grades.

He was appointed Chief Engineer of the Erie Railroad in 1905, and for five years, during its period of great expansion and improvement, was engaged in constructing four-track open cuts and tunnels, terminal facilities at Jersey City, improvements of the main line for low grade freight haul on the New York division, and the building of the Genesee River Railroad.

In 1910, for the fifth time, he returned to the Baltimore and Ohio Railroad, this time as Chief Engineer, and for another five years had charge of a heavy improvement program of double tracking, grade reduction, coal loading, and terminal facilities. During these ten years of intensive railroad construction activity, his office of Chief Engineer probably vouchered $2,000,000 per month for construction work between New York and Chicago.

Since 1915, Mr. Stuart has maintained consulting offices in New York City, passing on grade reduction schemes, developing mines, advising contractors on their bids, exploring the north coast of Cuba for sugar interests, studying terminal and port plans, and advising on hydro-electric projects. Numerous patents on labor-saving devices have been issued in his name, among others the Erie coal plant at Buffalo, which he installed.

Then the War came on and he became one of the technical advisors to the War Board of the Red Cross in connection with the economical transportation of its supplies overseas and their distribution in France. In 1917 he gave his services as an advisor on plans for Government handling of supplies and materials from points of manufacture in the United States to distribution points in France. He was instrumental in the selection of locations and layout for the Army bases at Port Newark Terminal, Norfolk, Philadelphia, Baltimore, and Charleston. When the Government took over the railroads of the country, he acted as Chairman of the Budget Committee of the United States Railroad Administration, and as such passed on expenditures of over $500,000,000 for wartime railroad improvements.

In 1930 he was Consulting Engineer to the Hydro-electric Power Commission of Ontario on the construction of the canal around Niagara Falls to the 600,000-hp. powerhouse below the whirlpool. Here he devised a wedge which, when placed in the forebay of the power plant, cut down loss of flow due to currents as the canal disgorged into the forebay.

In addition, Mr. Stuart has made extensive studies of the transportation difficulties of Manhattan and has been intimately associated with the many large problems of the 11 trunk-line railroads serving the Port of New York.

As Chairman of the Committee on the Value of Diverted Water for Transportation from Lake Michigan to the Gulf, aided by the engineering studies made in connection with the drainage problem of the Sanitary District of Chicago, he was able to obtain Government sanction for a diversion of an increased amount of water from Lake Michigan. Although this was opposed by the shipping interests, fearful of the effect of a lowered lake level on their docks, seasonal changes actually raised the level of Lake Michigan some two feet.

From 1920 to date, Mr. Stuart has been Consulting Engineer on the proposed Hudson River bridge project at 57th Street, New York. With the impending consolidation of eastern railroad systems, this 3,600-ft. span, estimated to cost $180,000,000, with approaches, appears nearer of consummation than ever before.

In the Society he has served both as Director (1909–1911) and as Vice-President (1920–1921). He is an active worker on committees, among them the Society's Publication Committee during 1907, 1910, and 1911; the Finance Committee, in 1920; and the Library Committee, in 1921. He has been the representative of the Society on the Board of Trustees of Engineering Foundation, Inc., and was president of that board during 1930. On several occasions he has contributed to the publications of the Society.

For diversion Mr. Stuart chooses golf and his avocation is working among the shrubs and plants on his 7½-acre home place in Essex Fells, N.J., where it is his delight to entertain his friends with true Southern hospitality.

Proceedings Goes Out On Time

Thirty-five years is a long time. For that period Proceedings has been issued in its present form, and in all those years has never failed to be issued on the date set for its publication. This wonderful record has been achieved through a remarkable *esprit de corps* on the part of all those concerned.

In the January 1931 number, appears one of the most difficult papers from a typographical standpoint that has ever been published in the Society's periodicals. The author and editors gave freely of their own time to get the manuscript into shape. When it reached the printer the difficulties were redoubled because relatively few typesetters can handle mathematical formulas, and this paper was liberally bestrewn with them. Even after the galley proofs came back, there was another struggle for proof readers and editors.

Notwithstanding all the hours of overtime, the fine record was still threatened. In this final emergency the printer and the binder came to the rescue. By heroic effort and close cooperation they were able to apply the short-cuts and economies of time learned by long years of experience in Society work—and thus a few more hours were saved. Thus, by dint of collaboration on every hand, the January number was enabled to go on time.

The record remains unbroken.

Final Ballot on Officers for 1931

33 West 39th Street
New York, N.Y.
January 14, 1931

To the Seventy-Eighth Annual Meeting
American Society of Civil Engineers:

The tellers appointed to canvass the ballot for officers of the Society for 1931 report as follows:

Total number of ballots received		4,346
Deduct:		
Ballots from members resigned	1	
Ballots from members in arrears of dues	8	
Ballots from non-corporate members	2	
Ballots with printed signature	6	
Ballots not signed	60	
Ballots from members who have died since voting	5	
Total not entitled to vote		82
Ballots canvassed		4,264
Void Ballots		2
Ballots counted		4,262

For President

Francis Lee Stuart	4,246
Scattering	6
Blank	10

For Vice-Presidents

Zone II:	John Needels Chester	4,209
	Scattering	1
	Blank	52
Zone III:	Henry Matson Waite	4,224
	Scattering	3
	Blank	35

For Directors

District No. 1 (Two to be elected):

Leslie Gilbert Holleran	4,214
Charles Adriance Mead	4,214
Scattering	3
Blank for one director	31
Blank for two directors	31

District No. 2:

Henry Robinson Buck	4,221
Scattering	3
Blank	38

District No. 6:

Edwin Kirtland Morse	4,219
Scattering	4
Blank	39

District No. 10:

Herbert Drummond Mendenhall	4,223
Scattering	2
Blank	37

District No. 13:

Frederick Charles Herrmann	4,226
Scattering	3
Blank	33

Respectfully submitted,

Albert B. Hager, *Chairman*

James H. Fitzgerald — H. Ridgway
W. L. Cadwallader — Thomas K. A. Hendrick
Harrison Tilghman — Allen P. Richmond, Jr.
F. A. Baker — *Tellers*

Norfolk Is Next

Norfolk, Va., has been selected as the place for the Spring Meeting, April 15–17, 1931. Those who have experienced the traditional hospitality of the South will know that everything possible will be done for their comfort and pleasure.

An interesting and attractive program has been prepared, in which men of national reputation will treat subjects of great interest to engineers. The entertainment features embrace an all-day trip to a number of historical points within easy reach of the Meeting headquarters.

All members will probably wish to again visit Jamestown, Williamsburg, and Yorktown and see the section around which so much of our Nation's history is written. They will find many things of interest—a beautiful harbor, on the water of which may be seen the ships of all nations; the Norfolk Naval Training Station, where they will be entertained with a special program; the large coal piers, which have made Norfolk the greatest coal port in the world; across the Elizabeth River, in Portsmouth, a ten-minute ride by ferry, the Navy Yard; and at Newport News, the famous Newport News Ship Building and Dry Dock Company. An opportunity will be afforded to visit all of these places with competent guides.

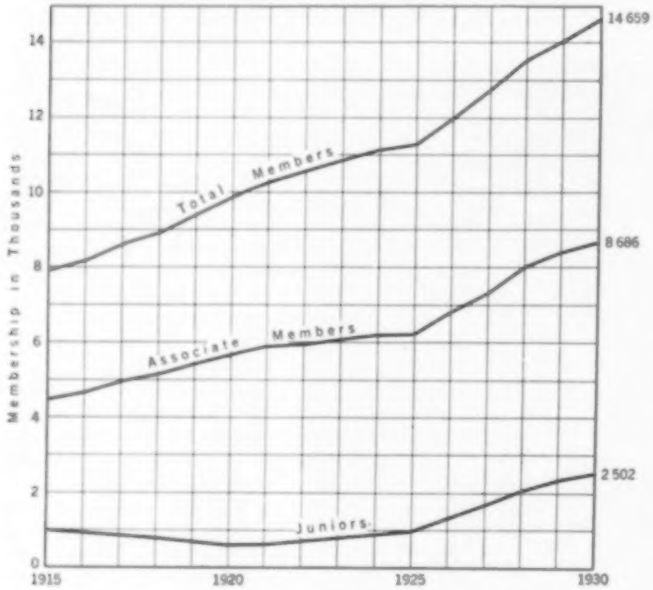
April is a delightful month in Virginia—flowers are blooming, birds are singing, and the temperature is just right for comfort and outdoor pleasure. There are beautifully planned golf courses—some of the best in the country—laid out along the shores of the Atlantic and among the bays and inlets, where every fairway presents an enchanting view.

If you can attend only one meeting this year, the local committee urges that it be the Norfolk Meeting. It promises a most profitable and interesting experience—one to be written in your book of "Happy Days." The old State of Virginia, the City of Norfolk, and the committee extend to every member a cordial welcome.

Trend of Membership Growth

Each year on January 1, as it becomes possible to analyze the growth of the Society in membership during the year just closed and to evaluate the trends that are apparent, interesting curves depicting these factors are made possible. Two such curves, dealing, respectively, with the net membership in the Society in various grades, and with the applications for admission as of the year ending December 31, 1930, are given herewith.

Outstanding and striking will be the first impression of these curves. As far as membership is concerned, the growth during the



GROWTH OF AMERICAN SOCIETY OF CIVIL ENGINEERS IN PAST 16 YEARS

past year has been approximately normal, or even somewhat better than normal. The graph for total membership indicates, if anything, a rather greater increase than during the previous year. With respect to applications, the record for 1930 is in excess of the two previous years, and almost at a maximum for the period since 1925.

To be viewed in their real light, these figures must be considered as applying to a year of abnormally low economic status for the profession as a whole. They would seem therefore to indicate that the membership activities of the Society are on a sound basis—not spectacular, perhaps, but consistent and able to weather the years of economic stress.

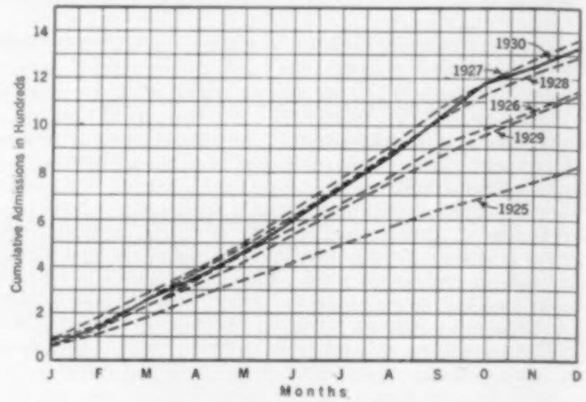
In connection with all membership statistics it may be noted that the Society as a body makes no official attempt to stimulate applications. Whatever growth has occurred has been due largely to the individual efforts of members. To them, therefore, belongs the credit for this remarkably consistent record.

President Coleman Goes Visiting

One of the pleasant duties of a president of the Society is to visit various centers of Society interest, represented largely by the Local Sections and Student Chapters. How well President Coleman has acquitted himself in this duty during 1930 is apparent from the sketch shown herewith.

It will be noted that only the Local Sections which were visited during the year have been marked on this map. At almost every city noted, one or more Student Chapters of the Society are also located. These likewise enjoyed the pleasure of a call from the President. In addition, of course, President Coleman made many visits to Headquarters and was in close touch with Society affairs in his home city, New Orleans.

Still other official visits were made during the year, some by Vice-Presidents and Directors of the Society in their respective districts, and others by the Secretary. It is thus that officers may



APPLICATIONS FOR ADMISSION
As Published in Proceedings Each Month

feel the impulse of contact with members on the firing line of engineering activity, may carry good words of cheer and news of Society happenings, and finally, may bring back inspiration for continuing and enlarging the scope of Society work.

Appointments of Society Representatives

H. H. QUIMBY, M. Am. Soc. C.E., was appointed by President Coleman to represent the Society on the American Standards Association. Mr. Quimby has heretofore represented the Society in the same capacity.

COL. WALTER F. WHITTEMORE, M. Am. Soc. C.E., has been appointed Society representative on the Educational Research Committee of the Research Board of Engineering Foundation.

CHARLES A. MEAD, M. Am. Soc. C.E., who has accepted President Coleman's appointment as representative of the Society for three years, on the Board of Trustees of Engineering Foundation of the four Founder Societies, is one of the Society's three representatives on that Board, the other two being George S. Davison, Past-President Am. Soc. C.E., and Frank E. Winsor, Vice-President Am. Soc. C.E.

CITIES INCLUDED IN PRESIDENT COLEMAN'S 1930 ITINERARY

A Preview of Proceedings

Three major papers on widely divergent subjects are to appear in the February issue of Proceedings—they deal with heavy railroad tunnel construction, surveying and mapping, and the measurement of irrigation water deliveries.

The Eight-Mile Cascade Tunnel on the Great Northern Railway

It has been the consistent practice of the Society to publish from time to time full technical accounts of the construction features of great engineering projects. By this means it has been enabled to present a vast amount of material to the profession in a unified, readable form not available from any other source. The forthcoming paper on the new Cascade Tunnel is the latest of such contributions. This paper, "The Eight-Mile Cascade Tunnel on the Great Northern Railway," is in three parts, each written by one intimately connected with the tunnel's construction.

In Part I, D. J. Kerr, M. Am. Soc. C.E., Assistant to the Vice-President, Operating Department, Great Northern Railway, St. Paul, Minn., introduces the subject by giving a short but fascinating outline of the history of the line, from 1889 when John F. Stevens, Past-President and Hon. M. Am. Soc. C.E., explored Marias Pass, to the present time. The author outlines the causes leading up to the improvements, and includes a discussion of snowfall with its incidental problems. For example, Mr. Kerr mentions one or two unit costs of constructing snow sheds.

Improvement of the Cascade crossing may be considered as four pieces of work: the eight-mile tunnel, the Chumstick line, the line revisions between Winton and Berne in the State of Washington, and the electrification from Wenatchee to Skykomish.

In the aggregate, the savings effected by improved alignment, lower summit, shorter mileage, and other items will be scarcely more than enough to pay interest on the entire investment but, according to Mr. Kerr, the railroad company justifies the project by considering the benefit which the system as a whole has received through the elimination of a weak link in its transportation chain.

Part II, by Frederick Mears, M. Am. Soc. C.E., Assistant Chief Engineer, Great Northern Railway, Seattle, Wash., is a description of the surveying methods and instruments used in constructing the tunnel. An account of the general plan of attack, the construction standards, the line improvement on the east and west slopes, and a comparison of the physical characteristics of the new and old routes comprises the larger part of this contribution.

Field work for the definite location of this tunnel included the precise location of the intermediate shaft. The author describes the process in three steps: (1) establishing the tunnel axis across the mountain tops between portals and projecting this line accurately into the valley of Mill Creek at the shaft site; (2) measuring the line and determining the exact location of the shaft with respect to the east and west portals; and (3) determining differences of elevation between the portals and the mouth of the shaft.

Part III, by J. C. Baxter, M. Am. Soc. C.E., formerly Vice-President and Contract Manager, A. Guthrie and Company, Inc., New York, comprises a study of the construction plans and discussion of methods involved. Particular attention is given by this author to the construction of camp facilities for employees. Sometimes the establishment of a camp required the clearing and disposal of as much as 50,000 board ft. of timber per acre. A detailed account of experience in the realm of drill sharpening, explosives, mucking, hauling, time-cycle studies, and concrete tunnel lining, is also included.

The pioneer tunnel between West Portal and the Mill Creek shaft was holed through on May 1, 1928, fifteen days ahead of schedule. The excavation of the tunnel was completed December 8, 1929, eight days behind schedule, after a total of 994,200 cu. yd. had been removed.

At an average rate of 75.5 ft. per day, the entire tunnel was lined a distance of 41,152 ft. On January 12, 1929, the first scheduled train ran through from the east. The entire contract was completed at an average rate of 36 ft. per day. In two appendixes, H. J. King, M. Am. Soc. C.E., adds considerable that will be of value to the construction engineer concerning drill-steel sharpening and concrete placing by pneumatic methods.

Surveys for Swift River Reservoir of the Boston Metropolitan Water Supply

Surveying an area about 82 sq. miles in extent for the proposed location of a reservoir site involves many problems of technic interesting to readers of Proceedings. The surveys in the Swift River Valley were tied together by a triangulation network in the general shape of two chains of quadrilaterals covering two of the major valleys. A plane system of coordinates was adopted such that its point of tangency at the surface of the earth was at an arbitrary point near the middle of the area of operation.

In addition to describing these problems, in his paper to appear in Proceedings for February, N. Leroy Hammond, Division Engineer, Metropolitan District Water Supply Commission, Boston, Mass., outlines the methods used in taking topography, the nature of field notes required, the cooperation required with the legal department in the examination of titles and in the adaptation of the aerial surveys.

Because of its timeliness, this paper was abstracted for preliminary review by readers of Proceedings in the December 1929, issue. The form as now published records practically the final status of the work from a surveying and mapping standpoint.

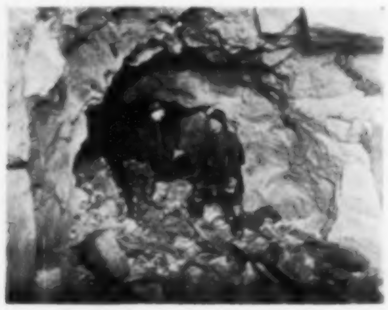
Measuring Irrigation Deliveries in the Punjab

The author of this paper, E. S. Lindley, M. Am. Soc. C.E., may well be considered an important liaison member between American engineers and public works activities in the Punjab. Particularly is this true in the field of irrigation and irrigation hydraulics, concerning which he has been a faithful contributor for the past eight years.

The present article is a concise description of a class of regulation devices designed to maintain a uniform irrigation water supply regardless of fluctuations in the main canals and primary laterals, emphasizing especially the latest improvements in older designs. Incidentally, the author presents a list of supporting references by which the reader may delve even deeper into the subject.

Cascade Tunnel Construction
Camp at Berne, Wash.

Loading the Break-Through Shot,
Main Bore, Cascade Tunnel



East Greets West on the Muck Pile
May 1, 1928, Cascade Tunnel

An opportunity for irrigation development that must be nearly unique is afforded by the natural conditions of the Panjab in British India.

The Indus and its five tributaries have here formed an enormous delta, with slight and nearly unbroken gradients. Rain occurs in only a few months of the year. It is heavy in the hills, but diminishes rapidly with distance from them; only in a narrow belt along the foot of the hills is agriculture possible on local moisture. At the further boundary of the province the average annual rainfall is only some two inches, and an appreciable part of the area may see one or even two years pass with less rain than this. The rivers are fed by the more abundant rainfall in the hills, and maintained at the driest season by melting snow and ice. There are therefore on the one hand supplies measurable not by hundreds, but by ten thousands of sec-ft.; on the other hand, thousands of square miles crying for water to make even habitation possible.

The opportunity and the need were such that a beginning was made even while the history of India was a succession of foreign aggressions and internal dissensions; what has grown into the Western Jumna Canal, irrigating to the west of Delhi, was begun in A.D. 1351, by the Pathan King, Firoz Shah Tughlak. After falling into disuse, this was revived and extended by Akbar two hundred years later, and further extended by Shah Jehan yet a century later. At the latter period water was brought also to Lahore, from the Ravi, by a channel that has developed into the Upper Bari Doab Canal. A century later, in A.D. 1740, the Sutlej was tapped on its left bank by a channel that has grown into the Sirhind Canal. Other canals with less scope for growth were also built in these periods, and by Diwan Sawan Mull, a famous viceroy of the Sikh administration.

The first irrigation activities of the British were concentrated on headworks, so as to make supplies less precarious at times when they were most needed. On the Western Jumna Canal this led to evils from which the tract has even now not quite fully recovered. The old channels, following the easiest alignments, blocked natural drainage lines and commanded only relatively narrow strips of low-lying land; with increased supplies the tract became seriously waterlogged, and its surface impregnated with salts. The canal system had to be radically redesigned from top to toe; and reconstruction was made difficult by the need for avoiding interruption of the supplies on which the tract depended.

In 1862 a first proposal was mooted for irrigating one of the tracts that were so arid as to be practically uninhabited. When this began to be considered seriously fifteen years later, irrigation schemes were in disfavor, and it was whittled down radically. It was failing, but fortunately men with vision and faith were able to command confidence; the scheme was extended, and it has grown into the Lower Chenab Canal. This canal commands 5,000 square miles, of which 3,600 square miles were desert without owner. With a capacity of 11,000 sec-ft., it is designed to irrigate 1,740,000 acres annually; but the actual annual irrigation is now 2,500,000 acres, being nearly 500 acres per sec-ft. of mean discharge, measured at the heads of farmers' ditches. It has cost \$11,500,000, while the value of crops grown on it is \$60,000,000 a year, and the extremely moderate charges made afford a net profit of more than 50 per cent on the cost.

Early in the present century, the position affecting future schemes was that the area calling first for development lay between the rivers Ravi and Sutlej. To the east, surplus supplies still available in the Sutlej were needed elsewhere; to the west, the Ravi and Chenab were fully utilized, and only the third river, the Jhelum, had surplus supplies available. The scheme then framed, and now operating some years, provided for carrying this water eastward, doing some irrigation, and dropping the surplus into the Chenab above an existing headworks. An equivalent amount of Chenab water thus released was taken off higher up the stream and carried eastward, again doing irrigation on the way, and was taken through the Ravi for irrigation of the tract needing it.

After this there remained, first a considerable tract between the Indus and the Jhelum; but the occurrence of belts of sandhills diminishes agricultural and irrigational prospects, and the neighboring province of Sind has opposed the schemes which have been framed for it, as endangering supplies to which it prefers a claim. Second, the lands along both banks of the Sutlej were served by a number of canals dependent on natural river levels for their supplies. A scheme, now well advanced toward execution, provides four weirs to secure supplies. These feed canals for giving the older irrigated areas their supplies with security, and other canals for carrying supplies that formerly passed unused, to further desert areas. Schemes for storage dams of enormous capacity have also been considered; one such is designed to carry an 11,000 sec-ft. canal through the months in which uncontrolled supplies are already fully utilized.

Completed schemes for weir fed canals have a total capacity of 67,000 sec-ft., cover 27,500 square miles, and irrigate 9,600,000 acres annually. Inundation canals and schemes submitted for administrative approval account for as much again. The former group of canals has cost \$75,000,000, annually raises crops worth \$200,000,000, and pays 20 per cent on its capital cost, furnishing 40 per cent of the total revenue of the province.

In India, irrigation water is paid for in terms of fixed acreage charges, assessed on the basis of the area of land actually cultivated. The canal system is designed to deliver this water to all holdings when it is running full. When the supply is insufficient to fill the canal, the water is shared proportionally.

The paper includes a description of the "Gate Modules," semi-modules, and modified Venturi-flumes, involved in this distribution practice. A short discussion of theory and its practical application makes this latest word from India something that will be carefully studied by all progressive engineers who have their "ears to the ground."

News of Local Sections

Central Ohio Section

Columbus was the scene of the regular monthly luncheon meeting of the Central Ohio Section, held December 11, 1930. Following a short business session, Dr. H. W. Gillette, Director of the Battelle Memorial Institute, spoke on the work of the institute, which is to conduct research in metallurgy, fuels, and allied subjects. Although the institute has been in operation only a little over a year, a large number of research problems in cooperation with industry are already under investigation.

Colorado Section

Various entertaining and instructive features have comprised the autumn activities of the Section. On September 15, 1930, following a dinner at the Denver Athletic Club, S. T. Weller, Engineer for the Denver Board of Water Commissioners, presented the subject of the "Eleven-Mile Canyon Dam."

October 11 was the date chosen for an outing and inspection trip. Members met at Colorado Springs and motored to Canon City. Following luncheon, a trip was made to the suspension bridge spanning the Royal Gorge. The speaker at the evening meeting was John T. Hainey.

On November 14, the Section met with the members of the Association of Western State Engineers, at the Denver Athletic Club. The feature of the occasion was the presentation of a paper by Joseph Burkholder, Chief Engineer of the Middle Rio Grande Conservancy District, on "The Conservancy Act and Its Application to Western Reclamation Problems."

The meeting on December 8 was open to ladies, and entertainment in the form of motion pictures was supplied by the General Electric Company.

Connecticut Section

A dinner meeting of the Section was held in Hartford, November 19, with 22 members in attendance. President Bishop announced the appointment of the Functional Expansion Program Committee as follows: J. P. Wadhams, Chairman, L. J. Carmalt, and H. J. Tippet. The speaker of the evening, Roscoe N. Clark, City Engineer of Hartford, chose for his subject "The South Meadows Dike." Moving pictures were shown of the work, which consists of building a dike to control the Connecticut River, reclaiming low land, and enlarging the airport by pumping fill.

Dayton Section

At the annual meeting of the Dayton Section, held December 8, 1930, the following officers were elected for the year 1931: W. W. Morehouse, President; John W. Graham, 1st Vice-President; C. S. Bennett, 2nd Vice-President; and J. F. Hale, Secretary-

Treasurer. The Local Membership Committee personnel for 1931 will consist of: W. W. Morehouse, Chairman, John W. Graham, C. S. Bennett, J. F. Hale, and N. J. Bell.

Duluth Section

Members of the Section, at a luncheon meeting held November 17, 1930, listened to a talk by John Wilson, City Engineer of Duluth, on the pollution of the St. Louis River and the Duluth Superior Harbor by sewage from the mining village north of Duluth and by industrial wastes from manufacturing plants. The attendance numbered 16 members and 5 guests.

Business discussion occupied the attention of the Duluth Section at its meeting on December 15, at which 12 members were present. Various committee reports were read and acted upon, and O. H. Dickerson presented the report of the Committee on Bridge Legislation. This provoked discussion on the subject of the excessive clearance heights required by the War Department, and the Secretary was instructed to send letters to Congressmen from Minnesota asking consideration of recommendations to be made by the American Engineering Council in the matter of legislation on bridges.

Illinois Section

At its weekly luncheon meeting of October 27, the Illinois Section inaugurated the practice of having an informal talk by one of its members. The first of these talks was given by President Morse, who spoke of his early experiences in the engineering profession, at a time when rifles were a necessary part of field equipment. C. H. Mottier addressed the meeting on November 7; and Colonel Goldsmith outlined the oil situation in the Oklahoma City field for those who attended the meeting of November 21.

An inspection trip through the new John G. Shedd Aquarium was the feature following the luncheon on November 14; and at the meeting on December 5, Mr. Clarke described the abatement of the mosquito menace in the Riverside Mosquito Abatement District.

At a meeting held December 17, 1930, at the Chicago Engineers' Club, the Section elected the following officers for the ensuing year: Paul Hansen, President; W. D. Pence, Vice-President (for two years); W. A. Rogers, Vice-President; F. G. Gordon, Secretary; and C. W. Haupt, Treasurer. The Local Committee on Membership will consist of: Henry Penn, L. C. Whittemore, and W. S. Lacher.

Maryland Section

Seventy-three attended a meeting of the Section held at the Engineers' Club in Baltimore, December 10. The feature of the occasion was an illustrated lecture by J. T. Thompson, Professor of Civil Engineering at Johns Hopkins University, on "The Freyssinet Method of Arch Construction." Use of this method has recently made possible the construction of the world's largest reinforced-concrete arch at Brest, France. In the business session that followed, these officers were elected for 1931: Warwick R. Edwards, President; and Wilson T. Ballard, Vice-President.

Milwaukee Section

A meeting of the Milwaukee Section was held December 12 at the City Club with 31 present, including seven members of the Marquette Student Chapter. The business session included approving both the Secretary's résumé of the year's activities and the Treasurer's report of the receipts and disbursements for the year. Election of officers for 1931 resulted as follows: C. U. Smith, President; J. L. Ferebee, 1st Vice-President; Prof. E. D. Roberts, 2nd Vice-President; and F. W. Ullius, Secretary-Treasurer. C. B. Whitnal, Secretary of the Board of Public Land Commissioners, then addressed the meeting on the subject of "State Planning."

Northeastern Section

A special meeting of the Section was held December 12 at the Engineers' Club in Boston, with 50 members and guests in attendance. Following luncheon, President Walker announced the appointment of the following as Contact Members for the Student Chapters in the Section: R. K. Hale, for Massachusetts Institute of Technology; F. H. Kingsbury, for Tufts College; P. H. Glover, University of Maine; L. W. West, Worcester Polytechnic Institute; and J. W. Childs, University of New Hampshire. At the close of the business meeting, the Section was favored by a talk by John Moses, Chief Engineer, the Boston Bridge Works, Inc., concerning the removal of the South Station Train Shed

Oklahoma Section

In connection with the Student Chapter of the University of Oklahoma, the Section held a meeting at Norman, Okla.,

Group in Attendance at Meeting of Oklahoma Section, November 21, 1930

on November 21. An interesting program was given by the students on the subjects of triangulation, plane table work, and mapping in the Wichita Mountains of Oklahoma.

Philadelphia Section

Many leaders in the engineering profession were included among the 70 members and guests who were present at the luncheon meeting of the Section held December 17. The guest of honor was J. F. Coleman, President of the Society, who gave an interesting account of the program of expansion carried on by the Society during the past year. Among the other speakers were George T. Seabury, Secretary of the Society.

On December 19, the regular meeting of the Section was held at the Engineers' Club, the subject of discussion being "Parkway and Park Development, and Preservation of Natural Beauty on Highways." The dinner was attended by 69 members, and the meeting that followed by 84. W. H. Connell, Director of the Philadelphia Tri-State Regional Planning Federation, was Chairman, and the speakers were John W. Keller, Chief Forester, Pennsylvania State Department of Highways, and W. Richmond Tracy, Chief Engineer, Union County (N.J.) Park Commission.

Porto Rico Section

At the annual meeting of the Section, held December 9, 1930, the following officers were elected for the ensuing year: Carlos del Valle, President; Ramón Ramos Casella, Vice-President; William H. Crago, Vice-President; Manuel V. Domenech, Fifth Member; and Reinaldo Ramírez, Secretary-Treasurer.

San Diego Section

On December 18, the San Diego Section held its annual meeting, at which officers for 1931 were elected as follows: Hans W. Jorgensen, President; Charles P. Williams, Vice-President; and Paul Beermann, Secretary. In accordance with the Section's constitution, the Executive Committee for the coming year will consist of these officers, together with former President Crosby.

San Francisco Section

A two-day excursion to the Mokelumne River hydro-electric project now being constructed by the Pacific Gas and Electric Company was made by 45 members of the San Francisco Section, October 18 and 19, 1930. Special features observed were the great rock-fill dam at Salt Springs, the novel flume construction methods, and the Tiger Creek Regulator.

A regular meeting of the Section was held at the Engineers' Club, October 21, with 175 members and guests present at the dinner and 225 attending the business and technical meeting

which followed. President Dewell announced that the Section had appointed W. H. Kirkbride its representative on a committee representing the Founder Engineering Societies. Other members of this committee are E. Stoddard, A. V. Gillon, and W. Bradley. The report of the Membership Committee indicated a net increase of two members, making the total membership 564.

St. Louis Section

At its annual meeting on November 24, the Section elected officers for the ensuing year as follows: F. W. Green, President; L. R. Bowen, Vice-President; H. F. Thomson, Councilor; H. E. Frech, Alternate Councilor and R. A. Willis, Secretary-Treasurer. The 35 members present heard an interesting talk given by Gardner S. Williams, of Ann Arbor, Mich., whose subject was a scheme for improving Mississippi River navigation and for preventing floods. President W. W. Horner reviewed the work of the committees who were in charge of the arrangements for the Fall Meeting of the Society. A very favorable report of the Finance Committee was heard, and an executive committee was appointed to keep the Section in touch with the various Student Chapters.

Tacoma Section

Thirty-four attended a meeting of the Section held December 8, at which the following officers were elected for 1931: J. L. Stannard, President; R. K. Tiffany, Sr., Vice-President; and Julian A. Arntson, Secretary-Treasurer. A motion was passed that the Section go on record as favoring the State License of Engineers Bill, soon to come before the State Legislature.

Student Chapter News

Agricultural and Mechanical College of Texas

A Christmas banquet, held by the Student Chapter of the Agricultural and Mechanical College of Texas at College Station, Tex., December 12, was the occasion for an interesting program. The group was honored by the presence of Mr. Howe, Vice-President of the Society, who gave an address, as did various members of the faculty. The topic under consideration was "The Possibilities for Civil Engineers."

George Washington University

From the annual report of the George Washington University Student Chapter, recently received at Headquarters, it is noted that the membership has, during the past year, enjoyed a number of meetings and varied activities. Among those who addressed the Chapter were: Dr. N. H. Heck, of the U.S. Coast and Geodetic Survey; and E. H. Tarwater, of the U.S. Bureau of Public Roads. Officers for the 1930–1931 school year were elected at a meeting on May 21, as follows: R. J. Alpher, President; J. K. Lokerson, Vice-President; R. E. Ask, Secretary; C. H. Kingsbury, Treasurer; and W. Shoemaker, Contact Committeeman.

Michigan State College

A social meeting of the Michigan State College Student Chapter was held November 19, at the college. At that time, George B. Vilas, General Manager of the Chicago-Northwestern Railroad Lines, gave the Chapter an illustrated address on the complicated yard system at Proviso, in Chicago, demonstrating the efficient handling of passengers in the central station in that city.

Oklahoma Agricultural and Mechanical College

Numerous meetings have been a feature of the Oklahoma Agricultural and Mechanical College Student Chapter's past year. Inspection trips, including a tour of eastern Oklahoma and Missouri, also proved of interest to the membership. At a meeting held April 23, 1930, officers for the school year 1930–1931 were elected as follows: W. N. Martin, President; J. Scroggs, Vice-President; P. F. Glendening, Secretary; D. M. Hipp and A. Sawallisch, Treasurers.

Oregon State Agricultural College

An increase of 124 per cent in the membership of the Oregon State Agricultural College Student Chapter during the past year has been reported to Headquarters. This membership of 56 constitutes 80 per cent of the college registration in the school of Civil Engineering. At the numerous meetings that were held, the members heard addresses on many important engineering subjects.

Pennsylvania State College

At a meeting held April 29, 1930, the Pennsylvania State College Student Chapter elected the following officers for the school year, 1930–1931: Allen Brandt, President; Peter Moore, Vice-President; Francis W. Kelly, Secretary; and Robert Bower, Treasurer. Among the speakers whom the members heard during the year were: Professor Thayer, of the Architectural Department, who spoke on "Historical Failures of Engineering Structures"; and Dean Sackett, of the School of Engineering, whose subject was "Formation of the Delta of the Colorado River."

POSTERS USED BY UNIVERSITY OF ILLINOIS STUDENT CHAPTER

Princeton Engineering Society

A meeting held December 16, 1930, was attended by 24 members of the Princeton Engineering Society Student Chapter. J. R. Munn, Vice-President of the Princeton Engineering Association, spoke on mining experiences in the Far West. Moving pictures of blasting done in construction of water highways and hydroelectric plants were shown.

University of Arizona

Some of the meetings of the University of Arizona Student Chapter during the past year were held jointly with meetings of the Arizona Section. These have been addressed by various important speakers, including President Coleman, Vice-President Howe, and Secretary Seabury. Officers for the year 1930–1931 were elected at a meeting held May 5, 1930, as follows: L. Laine, President; R. Houston, Vice-President; W. Norton, Secretary-Treasurer; and P. Kiernan, Corresponding Secretary.

University of Illinois

The University of Illinois Student Chapter has, during the past year, heard various notable speakers, among them: C. E. Grunsky, President of Engineering Council, who spoke on "Flood Control"; Ralph Modjeski, of New York, who spoke on "Suspension Bridges"; and Robert Ridgway, whose subject was "Some Features of the Rapid Transit of the City of New York." These speakers drew audiences of approximately 275, the average attendance at meetings throughout the year being 105.

University of Minnesota

At the meeting held May 22, 1930, the University of Minnesota Student Chapter elected the following officers for 1930–1931: Robert Ramsdell, President; Earl F. Porter, Vice-President; Charles G. Sonnen, Secretary; and John Swanson, Treasurer.

University of Nebraska

From the annual report of the University of Nebraska Student Chapter, it is noted that the members heard many interesting speakers during the past year. At a meeting held December 16, 1930, officers for the ensuing year were elected as follows: Lyle W. Mabbott, President; Lyman Bray, Vice-President; and C. A. Nelson, Secretary-Treasurer.

ITEMS OF INTEREST

Engineering Events in Brief

École Polytechnique Fédérale Celebrates Anniversary

From November 6 to 8, 1930, at Zürich, Switzerland, was celebrated the Seventy-fifth Anniversary of the École Polytechnique Fédérale or Eidgerössische Technische Hochschule. The name itself being a tongue twister, this technical high school is known as the E.T.H. The American Society of Civil Engineers was represented at this gathering of representatives from all over the world by Prof. K. E. Hilgard, M. Am. Soc. C.E., of Switzerland, from whose report this story has been abstracted.

On the forenoon of November 7, the principal function took place in the opera house. Many speeches were made and a number of honorary degrees were granted. Among the men receiving these were Dr. Einstein, a former student of E.T.H., and the author of the theory of relativity; and O. H. Ammann, M. Am. Soc. C.E., Chief Engineer of the Port of New York Authority, both of whom were awarded the honorary degree of Doctor, honoris causa. In the evening, after the midday banquet for 2,000 guests, interrupted by many speeches, a torch-light procession of the active students through a part of the city ended at the main hall where student fraternity festivities followed.

A general celebration, in which over 7,000 persons took part, was held the following evening, with several bands playing, refreshments, performances, and dances in nearly every room of the main building. Excursions to works or places of technical interest occupied the attention of eight groups of delegates on November 10. In the evening, a great many people listened to a very interesting illustrated lecture by Dr. O. H. Ammann on the construction of modern long-span bridges in the United States.

A number of jubilee publications relating to the celebration have been forwarded to Society Headquarters by Professor Hilgard, where they may interest the 20 or more recent graduates of E.T.H. who are members of the Society, as well as many others.

Friendly Cooperation

For several years the engineers of St. Louis have made it an annual practice to meet with local members of the State Legislature to discuss problems of common interest. The meeting during the current winter was held on the evening of December 20, 1930, at the Engineers' Club Building in St. Louis. This meeting was the fourth, held at two-year intervals, corresponding with the meetings of the State Legislature. Each one has strengthened the feeling, which prompted the original attempt, that a social gathering would yield beneficial personal contacts which would result in furthering the best interests of public welfare through the open consideration and discussion of policies tied up with engineering practice.

According to the published proceedings of this last meeting, papers of interest and value were considered. Among these was one on "Registration of Engineers," by Edward E. Wall, M. Am. Soc. C.E., presented in his absence by William C. Becker, Assoc. M. Am. Soc. C.E.; another on "Significance of the State Geological Survey," by Carl G. Stifel; still another on "Public Safety on the State Highway," by Charles M. Talbert, M. A. Soc. C.E.; and one on "Where Town and Country Meet," by A. S. Langsdorf.

Senators and Representatives, to the number of 22, comprised the guests of the evening, while 45 St. Louis engineers, many of whom are members of the Society, acted as hosts. The enterprise and public spirit behind these gatherings is further aided by the publication of the addresses, which tends to perpetuate in printed form the engineering ideals expressed.

COMING EVENTS

> AMERICAN SOCIETY OF CIVIL ENGINEERS
>
> *Spring Meeting Convenes in Norfolk, Va.*
>
> *April 15, 16, 17, 1931*

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS, INC.
Annual Meeting will be held in New York, February 16–19.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS
Fourth National Fuels Meeting will be held in Chicago, with headquarters at Stevens Hotel, February 10–13.

ENGINEERING INSTITUTE OF CANADA
Annual Meeting will convene in Montreal, February 4–6.

MIDWEST POWER ENGINEERING CONFERENCE
Fifth Conference will be held in Chicago, with headquarters at the Stevens Hotel, February 10–12.

MIDWEST POWER EXPOSITION
Fifth Exposition will be shown in the Coliseum, Chicago, February 10–14.

NATIONAL PAVING BRICK MANUFACTURERS ASSOCIATION
Twenty-fifth Annual Meeting will assemble at the William Penn Hotel, Pittsburgh, February 4–6.

WESTERN METAL AND MACHINERY EXPOSITION
The exposition will take place in San Francisco, February 16–20.

American Engineering Council Activity

Engineering Council held its annual dinner in Washington, D.C., January 16, attended by representatives of 25 national, state, and local engineering societies, whose joint membership totals 59,000 professional engineers. Maj.-Gen. Lytle Brown, M. Am. Soc. C.E., Chief of Engineers, U.S.A., spoke on "Engineers, Builders, and Executives," and Dr. George Otis Smith, Chairman of the newly created Federal Power Commission, spoke on the subject, "Words, Facts, and the Truth."

A committee has been formed by Engineering Council to study and report upon the objectionable action of certain governmental agencies encroaching on the private practice of consulting engineers.

A proposal to form a joint committee composed of members of the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, and American Engineering Council, to be known as Engineers' Water Power Policy Committee, has received the approval of the governing bodies of these societies.

A progress report of the Engineering and Allied Technical Professions Committee indicates that there are 115,205 engineers in the United States who hold memberships in 112 engineering and allied technical societies.

Commemorative Aeronautic Meeting

Among the notable figures in aeronautic work in recent years may be mentioned Glenn Curtiss, Chance Vought, and Daniel Guggenheim. To acknowledge their services a special commemorative meeting is to be held at the Engineering Societies Building, New York City, on February 25. All the Founder Societies, as well as the Society of Automotive Engineers, are to cooperate in this session under the leadership of the American Society of Mechanical Engineers. Each of these celebrated men will be eulogized and recognition will be given of his great achievements in this prominent field.

In addition, a commemorative exhibit will be held in the lobby of the Engineering Societies Building during the afternoon and evening. This will be largely devoted to the accomplishments of Glenn Curtiss and to a showing of his models of

early airplanes, such as special wing structures, as well as to examples of his later work. Other models will show Chance Vought's achievements, while the splendid work done by the Daniel Guggenheim Foundation will be illustrated by photographs.

Many noted engineers are cooperating to make this meeting a real tribute to the accomplishments in aeronautic engineering, including as many as possible of the early aeronauts. All engineers, especially members of the Founder Societies, will be welcome.

United Engineering Trustees, Inc.

At the December 15 meeting of the Board of Trustees it was announced that the four Founder Societies had approved of the change in name of Engineering Foundation, Inc., to United Engineering Trustees, Inc.

To refresh the memories of those who may be uncertain about the function of United Engineering Trustees, Inc., a few words of explanation may be in order. The corporation was formed May 11, 1904, to hold the legal title to certain real estate owned by the four Founder Societies, to hold trust funds given to these Societies jointly, and to advance the engineering arts and sciences in all their branches. The Engineering Societies Library, maintained under its guidance, occupies three floors of the Society building.

It is the legal entity by which 59,000 members of the four societies may perform certain specific acts which are governed by contracts. Other societies occupying space in the building bring the total number of engineers who have their headquarters in the building at 29 West 39 Street, N.Y., to over 80,000.

NEWS OF ENGINEERS

Vilas R. Rathbun, who was Designing Engineer of the Cushman Power Plant, now holds the same position in the Public Utilities Department, Station B, Tacoma, Wash.

Gerald McKinlay of Sacramento, Calif., is now associated with the Division of Water Resources, State Department of Public Works, holding the position of Associate Engineer of Dams.

C. A. Lauenstein, who has been Assistant Engineer, Spring Valley Water Company, is now Engineer of the San Francisco Water Department.

William F. Sheehan is now President of Sheehan, Fretts, and Tallamy, Consulting Engineers, Williamsville, N.Y. Mr. Sheehan was formerly employed as Resident Engineer, George C. Diehl, Inc., of the same city.

Maurice A. Warthen, recently with the Grier-Lawrence Construction Company, is now a Civil Engineer for Merritt, Chapman, Scott, Inc., New York, N.Y.

Luther J. Fellows has resigned his position as Inspector and Estimator, Long-Bell Lumber Company, Longview, Wash., and is now Superintendent, Power House Construction, Department of Public Utilities, Tacoma, Wash.

Samuel M. Fisher has accepted a position with the Wintroath Pumps, Ltd., Alhambra, Calif., as Assistant Sales Manager. He was recently with the Los Angeles County Flood Control District, as Chief Designing Engineer.

I. G. Grundel has recently made a connection as Civil Engineer with the Associated Oil Company, San Francisco, Calif. Prior to that, Mr. Grundel was Chief Engineer, Pacific Gillespie System, Inc., San Diego, Calif.

Raymond Radbill, formerly Engineer of the Good Roads Company, Inc., Moylan, Pa., has accepted a position as Manager of the Bituminous Service Company of West Chester, Pa.

Walter F. Wirth, at one time Superintendent of Construction, Cia National de Augas, San Salvador, Salvador, is now General Superintendent, Pavimentacion de Santa Ana, R. W. Hebard and Rene Kelhauer, Santa Ana, El Salvador.

O. G. Thurlow is at present Vice-President, Allied Engineers, Inc., Birmingham, Ala. Prior to that Mr. Thurlow held a similar position in the Alabama Power Company of the same city.

Richard Willis How, who has been an Engineer with the Letchworth Park Commission, Castile, N.Y., at present holds a similar position with the Genesse State Park Commission, Castile, N.Y.

Enrique Aguerrevere is now Caracas Representative, Paraguana Petroleum Corporation, Caracas, Venezuela. He was formerly Terminal Superintendent, Cia, Terminal Imperio, Tampico, Tamps, Mexico.

Eugene C. Hultman has been appointed Police Commissioner of Boston, having formerly been Fire Commissioner of the same city.

Robert W. Stiles, formerly Secretary-Treasurer of the Beretta-Stiles Company, San Antonio, Tex., has now become associated with the Engineering Department, Lone Star Gas Company, Dallas, Tex.

Edward S. Sheiry has accepted a professorship in Robert College, Istanbul, Turkey. Mr. Sheiry has previously been Designing Engineer, Charles H. Tompkins Company, Washington, D.C.

John V. Zahlen has recently changed his position with the Division of Water Resources, State Department of Public Works, Sacramento, Calif., and can now be reached in care of Empresas Publicas Municipales, Planta Guadalupe, Medellin, Colombia, S.A., where he is Hydraulic Engineer.

Albert L. Wilcox has now become associated with the Emprezas Electricas Brasileiras, S. A., Caixa Postal NL 883, Rio de Janeiro, Brazil, S.A. Mr. Wilcox was formerly Manager, The Foundation Company, Casilla 950, Santiago, Chile.

Robert L. Acker, who has been President of C. O. Peterson Company, Inc., Minneapolis, Minn., is now President of Rehn-Acker Corporation, 205 Lumber Exchange, Minneapolis, Minn.

Philip F. Auer has recently accepted a position as President, Smith, Auer Company, Inc., Clayton, Mo. He was formerly associated with Preston J. Bradshaw.

L. W. Barbour is now Refinery Manager of the Sinclair Refining Company Sand Springs, Okla. Prior to that, he was Manager, Production, Pipe Lines, and Refineries, Pierce Petroleum Corporation, Tulsa, Okla.

Oliver R. Bosso, who previously was with the Columbia Steel Corporation, is now with the Bridge Department of the Division of Highways, State of California, Oakland, Calif.

Charles R. Bourland has become Chief Engineer of the Smokeless Coal Company, Mount Hope, W.Va. Mr. Bourland formerly held the same position with the Fordson Coal Company, Stone, Ky.

Hans L. Christie, who was formerly Designing Engineer, Tower Department, American Bridge Company, Pittsburgh, Pa., has accepted a position as Structural Engineer with the Columbia Steel Company, Arcade Station, Los Angeles, Calif.

Charles W. Cunningham is now Draftsman of the American Bridge Company, Ambridge, Pa., and was formerly Instructor, Department of Civil Engineering, Rutgers University, New Brunswick, N.J.

Jorge Victor Dávila, at one time Civil Engineer, San Juan, Porto Rico, is now Engineer in Charge, Water and Sewage Purification, Department of Health of Porto Rico, San Juan, Porto Rico.

Anthony P. Dean is now associated with Empresos Publicas Municipales, Medellin, Colombia, holding the position of Superintendent of Hydraulic Construction. He was formerly Superintendent, Cushman Dam, Portland, Ore.

Earl K. Dewey, who has been with the Turner Construction Company, is now General Superintendent, Max B. Muller and Company, Inc., New York, N.Y.

Eric Fleming has accepted a position as Engineer and Architect with Schneider, Kleeman, and Werther, Architects, Newark, N.J. He held the same position with the Austin Company also of Newark.

Paul C. Gillette has been appointed New York Representative of the Empire Securities Company, Bridgeport, Conn. He was formerly Engineer, American Equities Reporting Company, New York, N.Y.

Arthur E. Gorman has resigned his position as Sanitary Engineer, Wallace and Tiernan Company, East Orange, N.J., and is at present, Western Sales Manager, Pardee Engineering Company, Chicago, Ill.

William Jesse Gray, formerly Assistant City Engineer, Port Arthur, Tex., is now Engineer for the Texas Company, Port Arthur, Tex.

George Halverson, who has been with the Carrier Engineering Corporation, Newark, N.J., is now Engineer and Draftsman with Myron S. Telles and Harry Halverson, Kingston, N.Y.

Floyd W. Hough, who has been connected with the Colorado River Project Los Angeles, Calif., is now Geodetic Engineer, Metropolitan Water District of Southern California, Beaumont, Calif.

Irving V. A. Huie is now President, Irving V. A. Huie, Inc., General Contractor, Saugerties, N.Y.

John B. Jackson, who is now Executive-Secretary, Works Managers Committee and General Purchasing Committee, General Motors Corporation, Detroit, Mich., was formerly on the Director-Staff of the same company.

Theodore P. Kilian has become Assistant Engineer, Port of New York Authority, New York, N.Y. He was until recently chief Draftsman, New York and New Jersey Bridge and Tunnel Commission, Holland Tunnel, New York, N.Y.

Donald H. McNeal, who has been heretofore Manager Building Promotion, McPhee and McGinnity Company, Denver, Colo., is now Merchandising Consultant, Evanston, Ill.

John B. Morrison is at present Manager of Sales and Chief Engineer, Ohio Corrugated Culvert Company, Middletown, Ohio. He was formerly Manager, Highway Bureau, Armco Culvert and Flume Manufacturers Association of the same city.

Fred J. Nebiker, who is now Office Engineer in charge of Florida Development Company, Everglades, Fla., formerly held the same position with the Barron and Collier Interests at the same address.

Harold Van Dyke Owens, who is President and General Manager of the Eastern Rock Products, Inc., Utica, N.Y., also holds the position of Secretary and Treasurer of the Dale Engineering Company of Utica, N.Y.

William H. Russell, now Manager, Dealer Division, Truscon Steel Company, 1505 Race Street, Drexel Hill, Pa., was formerly District Manager, Genfire Steel Company, also at Drexel Hill.

Hal J. Sams, formerly District Sales Manager, Santa Cruz Portland Cement Company, San Francisco, Calif., is at present, Engineer, A. Teichert & Son, Inc., 1846–37th Street, Sacramento, Calif.

Tage Werner has accepted a position with Arthur G. McKee and Company as Designer, after occupying the same position with the Cleveland Union Terminals Company, Cleveland, Ohio.

Claude R. Weymouth, who has been Construction Engineer, Froemming Brothers, Inc., Milwaukee, Wis., is Construction Superintendent and Engineer of the Paul C. Kroeck Construction Company of the same city.

Wilfred Ashenhurst White is now a member of the Stone and Webster Engineering Corporation at Wenatchee, Wash., and he was formerly Resident Manager, Puget Sound Power and Light Company, Port Angeles, Wash.

Trygve D. Groner, who has been Production Manager of Robbins and Myers Company, Springfield, Ohio, is now Secretary-Treasurer of The Whitney-Groner Company also of that city.

Kyrel E. Kirby is at present Chief Engineer, The Union-Terminal Company, Dallas, Tex. He was formerly Assistant Engineer, G. C. and S. F. Railway, Galveston, Tex.

Finley B. Laverty, at one time Structural Engineer, Meyer and Holler, Los Angeles, Calif., is now associated with the Los Angeles Flood Control District as Civil Engineer in the Hydrographic Department.

Milo S. Long, previously Division Superintendent, Dixie Construction Company, Birmingham, Ala., is now Superintendent of Miscellaneous Construction, Allied Engineers, Inc., Alabama Power Company, Birmingham.

Mason D. Pratt, formerly Consulting Engineer of Los Angeles, is now associated with the Strauss Engineering Corporation, Golden Gate Bridge, San Francisco.

Edward P. Quirk is now Assistant Engineer, New York Central Railroad, 466 Lexington Avenue, New York, N.Y. Prior to that, Mr. Quirk was Assistant Engineer, New York State Bridge and Tunnel Commission, and New Jersey Interstate Bridge and Tunnel Commission, New York, N.Y.

Roy E. Spear has resigned his position as Structural Designer, Kansas City Power and Light Company, Kansas City, Mo., and is at present Engineer, Standard Steel Works, North Kansas City, Mo.

Lee G. Warren is no longer with the Phoenix Utility Company, Hot Springs, Ark., where he has been employed as General Superintendent. He now holds the same position with the Arkansas Power and Light Company, Hot Springs, Ark.

Richard Muller, who has been Consulting Engineer, Government of Santo Domingo, Dominican Republic, is now President, Pan American Engineering Company, Washington, D.C.

. Octavio A. Acevedo is now Vice-President, Pan American Engineering Company, Washington, D.C., having formerly been Professor of Mathematics and Civil Engineering, Universidad de Santo Domingo, Dominican Republic.

Harold A. Barnett, formerly Assistant City Engineer, San Marino, Calif., is now a member of the firm, Barnett and Steele, Civil Engineers, Pasadena, Calif.

Walter K. Brownell is at present Structural Engineer for the United Engineers and Constructors, Inc., Philadelphia, Pa., and formerly held the same position with Philadelphia Improvements, P. R. R., Philadelphia, Pa.

Erle L. Collins has changed his position from Chief Engineer, Brooklyn Ash Removal Company, Brooklyn, N.Y., to President and General Manager, Collins Construction Company, Inc., 135 New York Avenue, Brooklyn, N.Y.

William W. Fineren, who has been Consulting Engineer, Jacksonville, Fla., is now Consulting Civil Engineer, and Assistant Professor of Mechanical Engineering, University of Florida, Jacksonville, Fla.

Dewey George Fishbeck has now been promoted to District Engineer, in the firm of Kalman Steel Company, Architects Building, Philadelphia, Pa. Mr. Fishbeck was formerly Sales Engineer.

Leroy D. Gifford is now Chief Engineer, California Taxpayers' Association, Subway Terminal Building, Los Angeles, Calif. He was Assistant Engineer, Olmsted & Gillelen, Los Angeles, Calif.

Clifford C. Keirle, formerly associated with Bruce Engineering Company, Omaha, Nebraska, is now a member of the firm, Group Engineering Company, 609 Merchants National Bank Building, Omaha, Neb.

Harlan H. Snyder has resigned his position with Mason and Hanger Company, 52 Vanderbilt Avenue, New York, N.Y., and is now President, Pierce Steel Pile Corporation, at the same address.

Elmer H. Brown is at present General Manager, National Bridge Company, 43 Exchange Place, New York, N.Y. He was formerly Construction Superintendent, J. G. White Engineering Corporation at the same address.

William P. Cottingham, who was City Civil Engineer of Gary, Ind., is at the present time Engineer for the Gary Railways Company in the same city.

Ray L. Derby, formerly Sanitary Engineer with Salisbury, Bradshaw, and Taylor, Los Angeles, Calif., now holds the same position with Stevens and Koon, Consulting Engineers, Portland, Ore.

Edmund C. Flynn, Professor of Civil Engineering, University of Santa Clara, Santa Clara, Calif., was heretofore Assistant Professor, Industrial Arts Department, Iowa State College, Ames, Iowa.

Robert A. Galbreath has resigned his position with Stevens and Wood, Inc., Battle Creek, Mich., and is now Resident Engineer, Allied Engineers, Inc., Jackson, Mich.

James C. Terry has become Assistant Engineer, the Caloric Company of the Pan American Petroleum and Transport Company, Caixa Postal, Sao Paulo, Brazil. He was at one time Locating Engineer, The Sao Paulo Tramway Light and Power Company, of the same city.

Changes in Membership Grades

Additions, Transfers, Reinstatements, Deaths, and Resignations

From December 11, 1930, to January 10, 1931

ADDITIONS TO MEMBERSHIP

ACKISS, ARNOLD STURTEVANT. (Jun., Dec. '30.) Chf. of Party, Field Eng., Whidden-Beekman Co., Boston, Mass.

ALLEN, PHILIP BERTRAM. (Jun., Dec. '30.) 2024 Sturtevant Ave., Detroit, Mich.

ANDERSON, HERBERT FRANCIS. (Jun., Nov. '30.) 542 Lexington Ave., Newport, Ky.

BAUMAN, EDWARD WALTER. (Assoc. M., Nov. '30.) Acting Engr. of Tests, State Highway Dept., 418 Sixth Ave., North Nashville, Tenn.

BOEHME, HERBERT HUGO. (Jun., Oct. '30.) South 720 Washington St., Spokane, Wash.

BOYER, LEE CALVIN. (Jun., Nov. '30.) Draftsman, Dravo Contr. Co., 1234 Vance Ave., Coraopolis, Pa.

BRANSFORD, HOWELL ALEXANDER, JR. (Jun., Dec. '30.) Insp., State Highway Dept., Box 324, Fayetteville, Tenn.

BROOKS, HAROLD PHILLIPS. (Jun., Dec. '30.) Junior Engr., Water Resources Branch, U.S. Geological Survey, 2413 Indiana Ave., Columbus, Ohio.

BRYANS, CLYDE VENROY. (Jun., Dec. '30.) Supt., National Constr. Co., Washington, D.C.

BUKOVSKY, ALEXIS PAUL. (Jun., Dec. '30.) Box 2589, Yale Station, New Haven, Conn.

BUNCH, LVERNON. (Assoc. M., Nov. '30.) Care U.S. Engrs.' Office, Rock Island, Ill.

BURGWIN, WILLIAM HAROLD. (Assoc. M., May '30.) Div. Constr. Engr., State Highway Dept., 304 Court House, Springfield, Mo.

BUSCH, CARL GERHARD. (Assoc. M., June '30.) With Los Angeles County Sanitation Dists.; 731 East Olive St., Bellflower, Calif.

CAPWELL, CARL WAYLAND. (Jun., Oct. '30.) 255 Sea Vale St., Chula Vista, Calif.

CLIFFE, LUTHER ELIOT. (Jun., Nov. '30.) 310 Woodland Rd., Sewickley, Pa.

COHEN, SIGMUND. (Assoc. M., Nov. '30.) Asst. Structural Engr., Eng. Div., Board of Water Supply, 8100 West Warren Ave., East Dearborn, Mich.

CONDUSO, GENARO. (Jun., Oct. '30.) Draftsman, New York Telephone Co., Newark Office, 146 Ridge St., Newark, N.J.

CRAGO, PAUL HOFFMAN. (Jun., Dec. '30.) Central Canovanas, Canovanas, Porto Rico.

CRAMPTON, HENRY EDWARD, JR. (Jun., Dec. '30.) 2880 Broadway, New York, N.Y.

CUNNINGHAM, PAUL JOSEPH. (Jun., May '30.) Aurora, N.Y.

DAY, ALLEN ZUMVORDE. (Assoc. M., Oct. '30.) Sales Engr., Igoe Brothers, 234 Poinier St., Newark, N.J.

DIXON, WILTON OTHO. (Assoc. M., Nov. '30.) Bridge Designer, State Highway Comm., Little Rock, Ark.

DOTEN, HENRY LEROY. (Assoc. M., Dec. '30.) Constr. Engr., Bridge Div., State Highway Comm., Augusta, Me.

ENZ, KARL ALEXANDER. (M., Nov. '30.) Cons. Engr., Tokyo-fu, Japan.

EVANS, THOMAS HAYHURST. (Jun., Dec. '30.) Instr., Dept. of Eng., Mechanics, Yale Univ., New Haven, Conn.

FAGAN, WILLIAM BERNARD. (Jun., Dec. '30.) Eng. Asst., Board of Transportation, 15 Second St., New York, N.Y.

FELD, CARL WOOLSEY. (Jun., Dec. '30.) Asst. Supervisor, M. of W. Dept., Reading Co., Atlantic City R.R., 100 Copley Rd., Upper Darby Pa.

FENNER, THEODORE. (Assoc. M., Dec. '30.) Asst. Engr., Westchester County Park Comm., Bronxville, N.Y.

FIELD, GEORGE ADDISON. (Assoc. M., Dec. '30.) Contr., Field & McCelvey, 312 Myrick Bldg., Lubbock, Tex.

FILLION, STANLEY HERBERT. (Jun., Dec. '30.) Instr., Civ. Eng., Worcester Polytechnic Inst., Worcester, Mass.

FLYNT, FRANK LE ROY. (Assoc. M., Dec. '30.) Civ. Engr., Sewer Design Dept., City of St. Louis, 326 City Hall, St. Louis, Mo.

FORTE, MATTHEW GEORGE. (Jun., Dec. '30.) Eng. Asst., Grade 3, Board of Transportation, New York, N.Y.

FRAPS, GEORGE SAUNDERS. (Jun., Dec. '30.) 218 South Abe St., San Angelo, Tex.

FREGOSI, ALBERT. (Jun., Dec. '30.) Engr., New York Telephone Co., 140 West St., New York, N.Y.

FRIEDERICH, LEWIS WENIGER. (Jun., Dec. '30.) Supt. of Constr., A. Friederich & Sons Co., 710 Lake Ave., Rochester, N.Y.

GAISER, GEORGE LINCOLN. (Assoc. M., Aug. '30.) Mgr., Carnegie Plant, McClintic-Marshall Co., Carnegie, Pittsburgh, Pa.

GALLOWAY, CLARAN FRANKLIN. (Assoc. M., Nov. '30.) Asst. Chf. Surv., Los Angeles County Road Dept., Los Angeles, Calif.

GATEWOOD, JOSEPH STRONG. (Assoc. M., Dec. '30.) Associate Engr., U.S. Geological Survey, Water Resources Branch, Tucson, Ariz.

GIDLEY, LOUIS PAUL. (Jun., July '30.) Insp., U.S. Govt., Box 138, Morgantown, W.Va.

GRAN, JOHN RUBEN. (Jun., Oct. '30.) With Bureau of Standards, Washington, D.C.

HARRISON, BRADSHAW. (Assoc. M., Dec. '30.) Asst. Hydr. Engr., State Div. of Water Resources, Public Works Bldg., Sacramento, Calif.

HARTUNG, HERBERT OTTO. (Jun., Nov. '30.) 406 Interstate Bldg., Kansas City, Mo.

HERTEL, RAYMOND ERNEST. (Jun., Nov. '30.) Care Div. of Management, Bureau of Public Roads, Washington, D.C.

HICKMAN, PAUL. (Jun., Dec. '30.) Asst. Engr., John A. Roebling's Sons Co., 72 Morgan Pl., Arlington, N.J.

HILL, FRANK SMITH. (Jun., Nov. '30.) Junior Highway Engr., Div. of Highways, Paris, Ill.

HOFFMAN, HERMANN CARL. (Jun., Oct. '30.) 63 Bassett St., New Haven, Conn.

HUGG, ERNEST BRANCH. (Jun., Nov. '30.) 698 Park Rd., Ambridge, Pa.

INGRAM, WILLIAM TRUITT. (Jun., Dec. '30.) 825 Cowper St., Palo Alto, Calif.

JACOBS, HARRY VICTOR. (Jun., Dec. '30.) Res. Field Engr., W. N. Brown, Inc., 1800 E St., N.W., Room 705, Washington, D.C.

JOHNES, ALFRED WISHART. (Jun., Dec. '30.) 317 South 22d St., Philadelphia, Pa.

KAEHRLE, MARTIN ALFRED, JR. (Jun., Dec. '30.) Junior Engr., The Port of New York Authority, New York, N.Y.

KAVANAGH, GERALD RODGERS. (Assoc. M., Aug. '30.) San. Engr., Wallace & Tiernan Co., Inc., 636 Power Bldg., Chattanooga, Tenn.

LAGANA, DOMINICK. (Jun., Oct. '30.) 2702 Curtis St., East Elmhurst, N.Y.

LAING, JOHN JOSEPH. (Jun., '30.) With Bureau of Public Roads, Alexandria, Va.

LANGLEY, GEORGE WASHINGTON, JR. (M., Aug. '30.) Engr., Sheboygan County Highway Dept., Sheboygan, Wis.

LAWRENCE, RAY ELLSWORTH. (Assoc. M., Dec. '30.) First Asst. Engr., Div. of Sanitation, State Board of Health, Lawrence, Kans.

LEONARD, ALBERT JOSEPH. (Jun., Dec. '30.) Asst. Engr., Transportation Equipment Corp., 230 Park Ave., Room 907, New York, N.Y.

LEROUX, JULES WILLIAM. (M., Dec. '30.) Dist. Mgr., Nashville Bridge Co., Nashville, Tenn.

LEUBUSCHER, FREDERIC HENRY LOUIS. (Jun., Dec. '30.) Roseland Ave., Essex Fells, N.J.

LIBUTTI, ALBERT. (Jun., Dec. '30.) 5 Tower St., Providence, R.I.

MACNISH, CHARLES FRASER. (Jun., Oct. '30.) Junior Engr., U.S. Engr. Dept., Cincinnati Dist., 413 Customhouse, Cincinnati, Ohio.

MCCARTHY, HAROLD THOMAS. (Jun., Dec. '30.) 392 Main St., Haverhill, Mass.

MCCASLAND, STANFORD PAUL. (Jun., July '30.) 655 Stockton St., San Francisco, Calif.

MARKHAM, EDWARD MURPHY. (M., Oct. '30.) Col., Corps of Engrs., U.S.A., Div. Engr., Great Lakes Div., 419 Federal Bldg., Cleveland, Ohio.

MEADE, ROBERT HEBER. (Jun., Dec. '30.) Lieut. (j.g.) C.E.C., U.S.N., 480 Clinton Ave., Brooklyn, N.Y.

MERCER, LESLIE BOYD. (Assoc. M., Nov. '30.) Structural Engr., Henry Simon, Ltd., S.A. Casilla de Correo 887, Buenos Aires, Argentine Republic.

MINEAR, VIRGIL LUTHER. (Assoc. M., Nov. 30.) Locating Engr., R. W. Hebard & Co., Santa Ana, Salvador.

NIESSEN, WILLIAM. (Jun., Dec. '30.) Draftsman, McClintic-Marshall Constr. Co., Pennsylvania Bldg., Philadelphia, Pa.

PATENAUDE, MERLE ROSCOE. (Jun., Dec. '30.) Henniker, N.H.

PACHECO, FRANCISCO HUGO ORTUÑO. (Jun., June '30.) 207 West 85th St., New York, N.Y.

RAFFETY, JOHN STANLEY. (Assoc. M., Oct. '30.) San. Engr., Hamilton County, 3430 Oakview Pl., Hyde Park, Cincinnati, Ohio.

RANTA, TOIVO WALDER. (Jun., Dec. '30.) Junior Topographic Engr., U.S. Geological Survey, Washington, D.C.

RAWHOUSER, CLARENCE. (Jun., Nov. '30.) 439 Lafayette St., Denver, Colo.

REHLER, JOSEPH EDWARD. (Jun., Nov. '30.) 114 West 238th St., Apartment 2K, New York, N.Y.

SAMPLE, CHARLES SCHULTZE. (M., Dec. '30.) Constr. Engr., Mo.Pac.R.R., St. Louis, Mo.

SCHOENE, CHARLES ANDREW. (Jun., Nov. '30.) Federal Highway Engr., Blacksburg, Va.

SCURRY, JOHN FRANCIS. (Jun., Nov. '30.) U.S.Q.B. 2859, Mounds, La.

SEELEY, DOUGLAS CHARLES. (Jun., Dec. '30.) Insp., Pittsburgh Testing Laboratories, Pittsburgh, Pa.

SELBY, CHARLES ARTHUR. (Jun., Dec. '30.) With Gen. Motors Export Co., 1775 Broadway, New York, N.Y.

SEVERNS, JOSEPH PAUL. (Jun., Dec. '30.) 12 Fountain Ave., Burlington, N.J.

SHELLENBARGER, LYELL ROWE. (Jun., Nov. '30.) Route 2, Hopkins, Minn.

SMITH, GEORGE HENRY. (Jun., Oct. '30.) Structural Steel Draftsman, Houston Structural Steel Co., Houston, Tex.

SMITH, ROBERT TRUMBULL. (Jun., Dec. '30.) 724 Realty Bldg., Spokane, Wash.

SPRINGER, CLIFFORD HARRY. (Assoc. M., Dec. '30.) Instr. and Associate, Gen. Eng. Drawing, Univ. of Illinois, 313 Transportation Bldg., Urbana, Ill.

STENSTRÖM, GUSTAF ALEXANDER. (Assoc. M., Dec. '30.) Concrete Checker and Designer, C. B. Comstock, New York, N.Y.

STILES, ERNEST MILO. (Assoc. M., Aug. '30.) Constr. Engr., City Engr. Office, 615 South 7th St., Tacoma, Wash.

STORRER, FREDERICK RAY. (Assoc. M., Oct. '30.) City Engr., Municipal Bldg., Dearborn, Mich.

Summers, Herman Winston. (Jun., Dec. '30.) Care U.S. Engr. Office, Cairo, Ill.

Sweeney, James Joseph. (Jun., Nov. '30.) Care State Highway Dept., Watertown, N.Y.

Tebow, Henry Jule. (Jun., Oct. '30.) 2033 F St., N.W., Washington, D.C.

Terry, James Kenneth. (Jun., Nov. '30.) With Div. of Eng. and Constr., City of Toledo, Toledo, Ohio.

Thomas, Huguenin, Jr. (Jun., Oct. '30.) Surveyman, U.S. Engr. Dept., Savannah, Ga.

Todd, Paul Emerson. (Assoc. M., Nov. '30.) Field Engr., Portland Cement Assoc., Los Angeles, Calif.

Trenam, Milton Edwin. (Jun., Dec. '30.) Office Engr., Acting State Geologist, Salt Lake City, Utah.

Tseng, Tsao Wen. (Jun., June '30.) Asst. Engr., Lunghai Ry., 3 East Small Bridge, Soochow, Ku, China.

Tyree, Oscar William. (Jun., Nov. '30.) 7845 Eighty-fourth St., Glendale, N.Y.

Vissers, Raymond. (Jun., Dec. '30.) 118 West 63d St., New York, N.Y.

Wagner, John Harold. (Assoc. M., Aug. '30.) Mgr. of Erection, McClintic-Marshall Co., New York Dist., 39 Broadway, New York, N.Y.

Wheeler, Charles Eugene, Jr. (Assoc. M., Nov. '30.) Engr. of Plant Operation, San. Dist. of Chicago, Chicago, Ill.

Wilcox, Buell Elsworth. (Jun., July '30.) Instr., Civ. Eng., Oregon State Coll., Corvallis, Ore.

Wilson, William Sidney. (Jun., Oct. '30.) 3730 First St., San Diego, Calif.

Woodfin, Claude. (Assoc. M., Dec. '30.) County Engr., Oktibbeha County, Potts Camp, Miss.

Zauher, Anthony John. (Jun., Nov. '30.) 310 Woodland Rd., Sewickley, Pa.

Membership Transfers

Bierschenk, Harry Eugene. (Jun., '25; Assoc. M., Dec. '30.) Engr., Goldberger-Raabin Co., Inc., 1718 Fulton St., Brooklyn, N.Y.

Bisset, Andrew Gustave. (Assoc. M., '24; M., Dec. '30.) Lieut. Commander, C.E.C., U.S.N., Div. Engr., U.S. Navy, Public Works Dept., Navy Yard, Philadelphia, Pa.

Burgess, Harold Thomas. (Assoc. M., '21; M., Dec. '30.) Civ. Engr., C. W. Blakeslee & Sons, Inc., 58 Waverly St., New Haven, Conn.

Cagle, Cecil Cobb. (Jun., '24; Assoc. M., Nov. '30.) Structural Designer, Capitol Steel & Iron Co., Oklahoma City, Okla.

Cosores, Noah. (Assoc. M., '22; M., Sept. '30.) Chf. Engr., Bridge Bureau, People's Comissariat of Ways of Communication, Moscow, Union of Socialistic Soviet Republics.

Edwards, James Leland. (Assoc. M., '27; M., Dec. '30.) Structural Engr., H. G. Balcom, 10 East 47th St., New York, N.Y.

Epstein, Abraham. (Assoc. M., '19; M., Dec. '30.) Structural Engr., 2001 West Pershing Rd., Chicago, Ill.

Franklin, Philip Augustus. (Jun., '12; Assoc. M., '18; M., Dec. '30.) Structural Engr., McClintic-Marshall Co., Oliver Bldg., Pittsburgh, Pa.

Fuller, Samuel Leslie. (Assoc. M., '20; M., Dec. '30.) Vice-Pres., John F. Casey Co., Box 1753, Pittsburgh, Pa.

Goldbeck, Albert Theodore. (Assoc. M., '14; M., Dec. '30.) Director, Bureau of Eng., National Crushed Stone Assoc., Washington, D.C.

Larson, Linné Clarence. (Jun., '26; Assoc. M., Nov. '30.) Asst. Civ. Engr., Bureau of Eng., San. Sewer Div., Los Angeles, Calif.

Lohr, William Shannon. (Assoc. M., '17; M., Dec. '30.) Prof. Civ. Eng., Lafayette Coll., Easton, Pa.

Magner, Nelson Wendell. (Jun., Jan. '28; Assoc. M., Nov. '30.) Junior Engr., Municipal Eng. Div., Panama Canal, Box 4, Balboa, Canal Zone.

Spencer, Raymond Dana. (Jun., '28; Assoc. M., Oct. '30.) Engr., Olmsted & Gillelen, 3964 Second Ave., Los Angeles, Calif.

Stanfield, Adrian Clyde. (Assoc. M., '19; M., Dec. '30.) Cons. Engr., Pana, Ill.

Wing, Sumner Paddock. (Assoc. M., '21; M., Dec. '30.) Civ. Engr., Bureau of Reclamation, Denver, Colo.

Reinstatements

Karp, Edmund Isidore, Jun., reinstated Dec. '30.

Peden, Leo Thomas, M., reinstated Dec. '30.

Poland, William Babcock, M., reinstated Dec. '30.

Ritchie, Edward Warren, M., reinstated Dec. '30.

Resignations

Ackerman, Bennet Hubert, Assoc. M., resigned Jan. '31.

Adams, Merton Stephen, Jun., resigned Jan. '31.

Anders, Daniel Webster, Assoc. M., resigned Dec. '30.

Baxter, Ellery Read, Jun., resigned Dec. '30.

Bennett, Manche Owen, Assoc. M., resigned Dec. '30.

Benson, Frank Robert, Assoc. M., resigned Dec. '30.

Biedermann, Adolph Celestin, Assoc. M., resigned Dec. '30.

Brewer, Richard Nelson, Jun., resigned Dec. '30.

Brown, Levant, M., resigned Dec. '30.

Burr, Myron Carlos, M., resigned Jan. '31.

Canady, Curtis Marion, M., resigned Jan. '31.

Carr, Dean Orrice, Assoc. M., resigned Dec. '30.

Crowley, Charles James, M., resigned Dec. '30.

Darre-Jenssen, Lauritz, Jun., resigned Dec. '30.

De Bardeleben, James Mitchell, Jun., resigned Dec. '30.

De Wyrall, Cyril, Affiliate, resigned Dec. '30.

Duncanson, Dougald Henry, M., resigned Dec. '30.

Engstrom, Roy Victor, M., resigned Dec. '30.

Ezell, Estill Edwin, Jun., resigned Dec. '30.

Fellows, Fred George, Assoc. M., resigned Dec. '30.

Field, Francis Eugene, Jun., resigned Dec. '30.

Freeman, Harmon Martin, Assoc. M., resigned Dec. '30.

Gelwix, Daniel Edmund, Assoc. M., resigned Dec. '30.

Golden, William Anthony, Assoc. M., resigned Dec. '30.

Goldman, Samuel Robert, Jun., '21; Assoc. M., '27; resigned Dec. '30.

Haney, Albert Paul, Assoc. M., resigned Dec. '30.

Hermessen, John Louis, Assoc. M., resigned Dec. '30.

Hummer, John William, Jun., resigned Dec. '30.

Hunt, Harry Hauver, Affiliate, resigned Dec. '30.

Immick, Hollis Douglass, Assoc. M., resigned Jan. '31.

Jackson, James Granbery, M., resigned Dec. '30.

Johnson, Henry Stuart, M., resigned Dec. '30.

Kelly, Prescott Vail, Assoc. M., resigned Jan. '31.

Kline, Zoltan, Assoc. M., resigned Jan. '31.

Lundoff, Clemens Waldemar, Assoc. M., resigned Dec. '30.

McClintock, Hallett Edward, M., resigned Dec. '30.

McLachlan, Duncan William, Assoc. M., resigned Dec. '30.

Manton, Arthur Woodroffe, M., resigned Dec. '30.

Mead, Royal Lee, Assoc. M., resigned Dec. '30.

Metcalf, William Lovering, Jun., resigned Dec. '30.

Mullican, NaAmon Spencer, Assoc. M., resigned Dec. '30.

Oakley, Kenneth Harrington, Jun., resigned Dec. '30.

Olmstead, Harry Francis, Assoc. M., resigned Dec. '30.

Orr, Charles Seay, Jun., resigned Jan. '31.

Petersen, Randolph Joseph, Jun., resigned Dec. '30.

Piepmeier, Bion Harman, M., resigned Dec. '30.

Porter, Charles Robert, Assoc. M., resigned Dec. '30.

Prack, Arthur Edward, Assoc. M., resigned Dec. '30.

Roberts, Clifford James, Jun., resigned Dec. '30.

St. Clair, William Thaddeus, resigned Dec. '30.

Schelbe, Thomas Gilbert, Jun., resigned Dec. '30.

Sherzer, Allen Firman, Assoc. M., resigned Dec. '30.

Smart, Clinton Hayner, Affiliate, resigned Jan. '31.

Smith, J. George, Assoc. M., resigned Dec. '30.

Sparrow, William Warburton Knox, M., resigned Dec. '30.

Stephens, Hamilton Morton, M., resigned Dec. '30.

Stewart, Alanson Eugene, Assoc. M., resigned Dec. '30.

Wardlaw, James Thompson, M., resigned Dec. '30.

Weaver, Earll Chase, Assoc. M., resigned Dec. '30.

Wheeler, Darwin Frederick, Jun., resigned Dec. '30.

Whildin, William Gwilym, M., resigned Dec. '30.

Wood, Winthrop Barrett, M., resigned Dec. '30.

Deaths

Brataggr, Stoerk Johan. Elected M., June 3, 1915; died Aug. 29, 1930.

Carter, Edward Carlos. Elected M., Apr. 4, 1888; died Dec. 23, 1930.

Dennis, Walter. Elected M., June 16, 1919; died Dec. 6, 1930.

Gahagan, Walter Hamer. Elected Jun., Sept. 5, 1888; Assoc. M., July 1, 1891; M., Apr. 3, 1901; died Dec. 18, 1930.

Howe, William Chaffin. Elected Assoc. M., Sept. 2, 1914; died Sept. 16, 1930.

Johnston, Horace Greeley. Elected M., Sept. 7, 1887; died Dec. 10, 1930.

King, Harry Wheelock. Elected Affiliate June 19, 1891; died Apr. 14 1928.

Linton, Harvey. Elected M., Oct. 5, 1892; died Dec. 18, 1930.

Marsh, Kenneth Ames. Elected Assoc. M., Dec. 6, 1920; died Aug. 4, 1930.

Purdy, Samuel Moreau. Elected M., May 3, 1910; died Jan. 2, 1931.

Samuel, George Frederick. Elected M., Sept. 6, 1910; died Nov. 5, 1930.

Sharts, Stanley Rush. Elected Assoc. M., Dec. 1915; M., Nov. 26, 1918; died Dec. 5, 1930.

Taussig, Hubert Primm. Elected M., Apr. 4, 1888; died Dec. 21, 1930.

Van Zile, Harry Lee. Elected Assoc. M., Jan. 1886; M., Oct. 1918; died Jan. 6, 1931.

Vaughan, James Russell. Elected Jun., Nov. 11, 1929; died Dec. 16, 1930.

Witt, Carlton Carpenter. Elected M., Apr. 6, 1909; died Dec. 17, 1930.

Woodard, Wilkie. Elected Assoc. M., May 4, 1904; M., May 6, 1914; died Nov. 10, 1930.

TOTAL MEMBERSHIP AS OF JANUARY 10, 1931

Members	5,819
Associate Members	6,186
Corporate Members	12,005
Honorary Members	17
Juniors	2,539
Affiliates	134
Fellows	7
Total	14,702

Men and Positions Available

These items are from information furnished by the Engineering Societies Employment Service with offices in Chicago, New York, and San Francisco. The Service is available to all members of the contributing societies. A complete statement of the procedure, the location of offices, and the fees is to be found on page 87 of the 1930 Year Book of the Society. Unless otherwise noted, replies should be addressed to the key number, Engineering Societies Employment Service, 31 West 39th Street, New York, N.Y.

Men Available

BUILDING CONTRACTOR'S MANAGER; Assoc. M. Am. Soc. C.E.; technical graduate with 25 years practice. Experienced in designs, estimates, contracts, material purchases, planning, supervision, and management of general building construction work. Opportunity desired to take over the active management of building contractor's organization. Available soon. C-8528.

GRADUATE ENGINEER; Jun. Am. Soc. C.E.; 27; married; three and one-half years state and Federal work; experienced in sampling, testing construction materials, construction inspecting, stream gaging, installation, maintenance of river gages, and related office work; well grounded in theory of hydraulic engineering; wants work with consulting engineer, contractor, field or office, on hydraulic engineering. C-8536.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; university graduate, 1929; age 23. One year of work in surveying; one summer with construction company. Desires work as beginning draftsman or with construction company. Will do any kind of work. Available at once. Location in United States preferred. C-8544.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; age 32; married; seven years experience in hydraulic, navigation, and power investigations and in research, including models; three years experience on surveys, and in design and construction of bridges and irrigation structures. Desires investigation work in any of above fields. B-741.

JUNIOR CIVIL ENGINEER; age 28; West Virginia University; over six years field experience, railroad, dam, highway, and miscellaneous surveys. Bulk of experience on railroad survey and construction, mainly bridges. Can take charge of party on survey or construction. Location immaterial. Salary secondary to the right opportunities. C-8221.

YOUNG CIVIL ENGINEERING GRADUATE; desires position as engineering sales representative for local or foreign service; age 24; single. Five years of engineering experience confined chiefly to municipal construction work; also extensive executive and sales experience. Understands uses and possibilities of construction equipment. Can furnish good references. C-7322.

STRUCTURAL ENGINEER, ESTIMATOR, CONSTRUCTION MANAGER, Assoc. M. Am. Soc. C.E.; 36; married; licensed professional engineer; good mixer. Six years field experience; ten years with two prominent contractors in design; estimating flatslab, beam, and girder; tin pan systems; steel and slow burning; estimating industrial, commercial, and residential structures; familiar with various floor systems and their economies. C-8566.

RESIDENT ENGINEER, Assoc. M. Am. Soc. C.E.; age 33; married. Heavy foundations and structures in ocean and water-logged sites; power plant supervision from foundations to equipment installation and interior finish; industrial and oil refinery structures, piping, sewers. Design, estimates, control of costs. Available now. Location, Pacific Coast, Europe, or Africa. C-8562-3012-A-4.

CIVIL ENGINEER; graduate New York University, 1930; age 28; single; desires position with construction firm or structural fabricating concern; two and one-half years experience, field and drafting board. Location and salary immaterial. C-7953.

JUNIOR ENGINEER; 28; married; instrumentman or party chief on surveys or construction; C.E. degree, West Virginia University; over six years field experience with mining companies, U.S. Engineers, highway and railroad work; miscellaneous surveys and reinforced concrete construction. Salary open. Location immaterial. C-8022.

MUNICIPAL CONSTRUCTION ENGINEER; Jun. Am. Soc. C.E.; age 24; unmarried; graduate in civil engineering; three and one-half years experience in municipal work as assistant and resident engineer. Desires position with city or consulting engineer in West, South, or Middle West. Permanence, with future, of primary importance; references. Available short notice. C-8586.

STRUCTURAL DESIGNER, Jun. Am. Soc. C.E.; B.S. in C.E.; seven years experience in mill building, bridge and road design, and detail, including steel, reinforced concrete, and timber construction; one year responsible charge of design with large chemical corporation. Immediately available. Excellent references. Desires New York location. C-8598.

CONSTRUCTION EXECUTIVE, SUPERINTENDENT, OR ENGINEER, Assoc. M. Am. Soc. C.E.; 50; married; graduate civil engineer, Sheffield Scientific School, Yale University; 20 years full charge construction, railroad, plain and reinforced concrete, bridge, highway, and all kinds municipal work, sewerage systems, foundations, and industrial and commercial buildings. Can use Spanish. Location, New York, South, or foreign. C-675.

CONSTRUCTION ENGINEER OR SUPERINTENDENT, M. Am. Soc. C.E.; over 30 years going abroad building things—railways, hydro-electric and reinforced concrete projects, wharves, and industrial buildings. Experience West Indies, South America, France, Far East. Speaks Spanish. Can handle by administration, or supervise local contractors, write specifications, and make contracts. Will go anywhere. A-5380.

CIVIL ENGINEER, Assoc. M. Am. Soc. C.E.; 14 years experience; desires responsible position, preferably on highway or railroad construction, or location; considerable experience in general and triangulation surveys. Speaks and writes Spanish and French. Location immaterial. B-9765.

CIVIL ENGINEER; married; American; graduate from Delft University; eight years experience as superintendent, expeditor, estimator, and job runner, apartment house, mill, bank, loft, and hotel buildings; desires position with general contractor. Willing to go anywhere. Speaks French, German, Dutch, and a little Spanish. C-5430.

GRADUATE CIVIL ENGINEER, Jun. Am. Soc. C.E.; age 30; American; six years experience building construction; one year in field and five years detailing, checking, and designing concrete and steel, and estimating. Available at once. C-8304.

ENGINEER, Assoc. M. Am. Soc. C.E.; graduate in law and personnel administration; 20 years experience in construction, purchasing, promotion, investigation; seeks position, preferably in New York City but will go elsewhere, where engineering experience and legal knowledge may be combined; local representative or limited traveling. Available on short notice. B-5501.

CIVIL ENGINEER, Assoc. M. Am. Soc. C.E.; single; executive type with an outstanding record of accomplishment; 20 years experience; 12 years in Latin-American countries, with work on highway and railroad location and construction, harbor development, municipal improvements, investigations and reports; has negotiated several large foreign contracts. Location secondary. B-4130.

GRADUATE CIVIL ENGINEER; seeking connection; has experience in under-water work; one year with prominent consulting engineering firm on hydro-electric, railroad electrification, appraisal operations; water supply work with pitometer company; past three and one-half years in subway construction, doing field engineering; design of fluming, timbering, underpinning; claims, estimating, etc. C-8090.

CIVIL ENGINEER, M. Am. Soc. C.E.; 25 years experience on hydro-electric, irrigation, and highway work, and in exploration. Intimately acquainted with conditions in Central America and West Indies. Prepared to make investigations and reports or to superintend construction or operation of Latin America projects. B-7788.

CIVIL ENGINEER, Assoc. M. Am. Soc. C.E.; 39; 17 years active engineering experience, field and office; specialties power houses and railroad terminals; design and construction of industrial buildings, heavy foundations, foundations on glacier formation; general underground and superstructure work. Executive, seeking greater responsibilities. Married; prefers East but will go anywhere, if right proposition. C-1445.

STRUCTURAL STEEL AND REINFORCED CONCRETE DESIGNER, Jun. Am. Soc. C.E.; 30; American; Massachusetts Institute of Technology, Civil Engineer graduate. Experienced in design and construction of steel office buildings, industrial buildings, warehouses, foundations. Desires position with leading architects, consulting engineers, or contractors. Desires responsible position. Able to direct and to work independently. C-6533.

ESTIMATOR, Assoc. M. Am. Soc. C.E.; graduate structural engineer, Massachusetts Institute Technology; 35; married; desires position, small or medium-size construction firm, as office man; 12 years practical experience estimating, designing, taking care subcontractors, all types structures. Intimate knowledge of all phases of contracting. Excellent references. Will consider profit-sharing arrangement, or extremely low salary. B-1168.

ENGINEER, EXECUTIVE, M. Am. Soc. C.E.; 41; graduate civil engineer with degrees. Broad experience in structural and industrial work, including allied mechanical lines. B-6046.

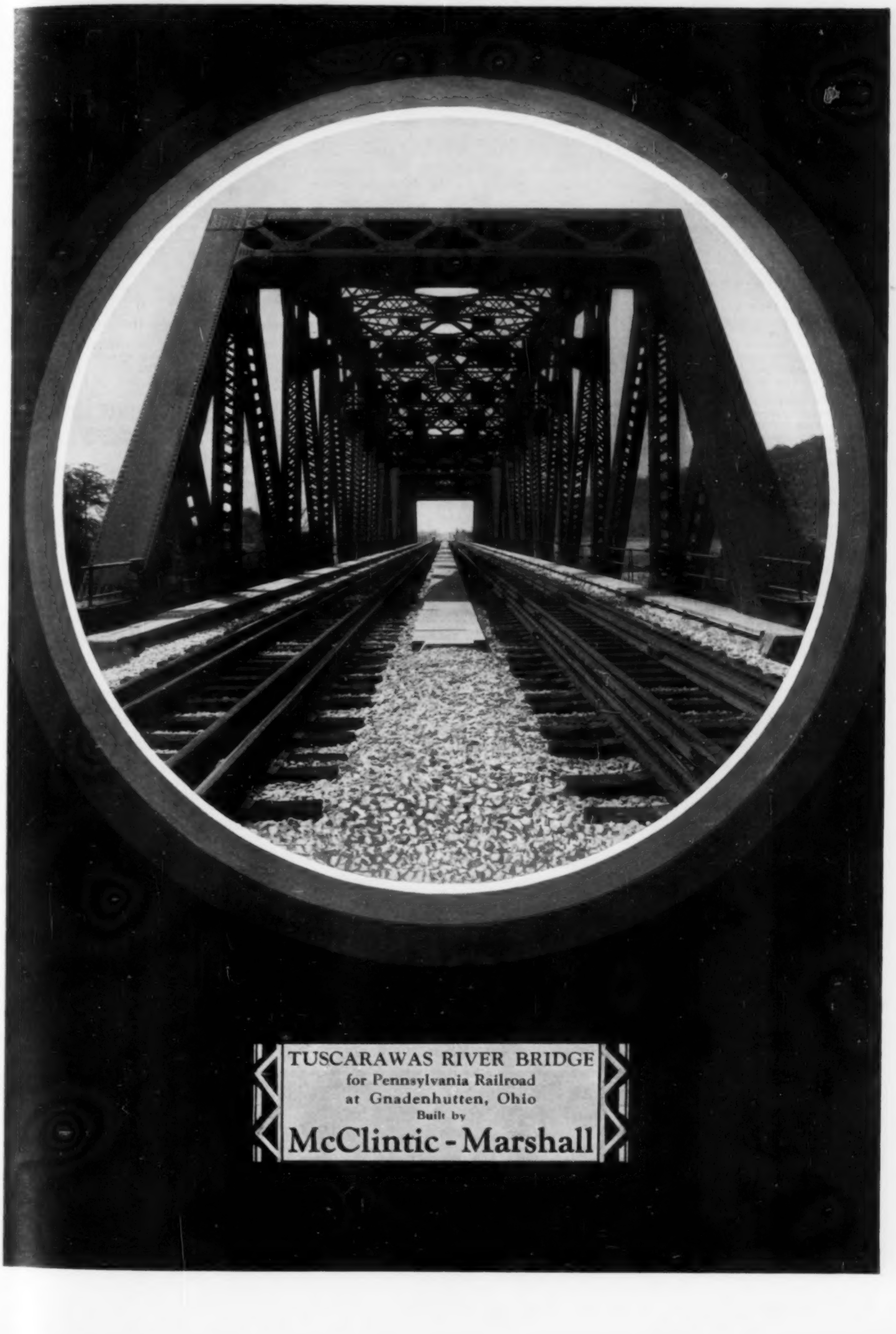
CIVIL ENGINEER; 27; two years experience oil and gas production, pipe line, pump station, and compressor station construction; three years experience, supervision and design of small building construction, alteration projects, and miscellaneous engineering work in office of consulting engineer. Executive ability. C-5825.

STRUCTURAL ENGINEER, Jun. Am. Soc. C.E.; age 28; married; graduate; five years responsible experience on design of industrial and office buildings, piersheds, warehouses, airplane hangars, water supply projects, and large steel roof signs. Able to direct and work independently. References. C-1833.

MUNICIPAL AND SANITARY ENGINEER, Assoc. M. Am. Soc. C.E.; married; graduate sanitary engineer; 20 years designing and construction experience, covering sewerage, drainage, water supply, flood control, paving, real estate development; investigations, estimates, and reports. Desires responsible position in New York Metropolitan district. B-1829.

GRADUATE ENGINEER, Assoc. M. Am. Soc. C.E.; 35; married; 14 years varied experience in surveying, drafting, designing, superintendence, sewerage disposal, water supply, testing and inspection of steel, railroad maintenance, cost accounting, research testing, sales promotion on containers, and sales engineering. Speaks German. Licensed civil engineer, New York, New Jersey. C-8614.

CONSTRUCTION SUPERINTENDENT, Assoc. M. Am. Soc. C.E.; married; graduate Union College; licensed professional engineer and surveyor; seven years experience with general contractor. Has superintended the construction of schools, factory developments, medical and office buildings. Experienced in estimating, also in the design and construction of airports and their buildings. C-8571.


TUSCARAWAS RIVER BRIDGE
for Pennsylvania Railroad
at Gnadenhutten, Ohio
Built by
McClintic-Marshall

CIVIL ENGINEER, Jun. Am. Soc. C.E.; member Society of American Military Engineers; graduate engineer; age 26; three years experience in river and harbor work, concrete pier construction, round and sheet-pile work; in charge of survey and sounding parties; experience in designing and drawing plans for floating plant. C-8619.

GRADUATE CIVIL ENGINEER, Assoc. M. Am. Soc. C.E.; New York State license; engineer and surveyor; 18 years responsible charge of river and canal construction; 4 years on erection of mill buildings and industrial plants; 4 years supervising construction of large hydro-electric projects. C-827.

CIVIL ENGINEER, Jun. Am. Soc. C.E.; age 28; married; three years construction experience as superintendent and assistant superintendent; two years selling and sales correspondence; two years railroad location and construction. Available immediately, domestic or foreign. C-7491.

STRUCTURAL ENGINEER, Assoc. M. Am. Soc. C.E.; graduate leading eastern university; 30; married; six and one-half years broad experience; three and one-half years fabricators' drafting, estimating, engineering departments, large bridges, buildings, heavy construction; three years design mill buildings, industrial plants, railway work, and office buildings. Desires position structural designer, assistant engineer, or sales engineer. Good personality. C-7922.

ENGINEER; civil engineering graduate; age 25; single; served apprenticeship as mechanical draftsman, shop experience; construction of gas compressor stations. Desires additional compressor station work, association with contractor, or sewerage work with city. Available February 15th. C-8559.

ENGINEER, M. Am. Soc. C.E.; 52; married; qualified to locate and construct irrigation works, design and construct sewers, pavements, and municipal works. City engineer and executive. Location immaterial, preferably West. C-8622-311-A-2. San Francisco.

CONSTRUCTION ENGINEER OR SUPERINTENDENT, Assoc. M. Am. Soc. C.E.; graduate engineer; age 30; married, desires position as contractor's engineer or superintendent. Nine years experience; estimator; building highways and railroads; in charge of general concrete construction, rock and soft ground shafts and tunnels, caissons and pipe lines. Available now. C-8584.

CIVIL ENGINEER, Jun. Am. Soc. C.E.; age 26; single; American; college graduate; one and one-half years in construction, buildings, and oil storage plant; one and one-half years in railroad electrification work as rodman and draftsman. Desires position in field with railroad or construction company. Location immaterial. C-8602.

HYDRAULIC ENGINEER; 43; married, supervision of industrial and municipal water development, production and distribution systems; operation of surface and deep well systems; appraisals, investigations, and reports made on water-producing properties, pumping plants, and distribution works. Location west of Rockies. C-8631-311-A-3. San Francisco.

ENGINEER, Jun. Am. Soc. C.E.; graduate; B.S. and C.E. degrees; age 30; single; four years inside structural experience; two years highway experience; one year technical accounting; knowledge of technical statistics. Salary and location open. Desires position structural design, computations, valuation, assistant to consulting engineer. B-6646.

CIVIL ENGINEER, Jun. Am. Soc. C.E.; graduate; age 31; married; two years experience in survey; six years construction experience on structural steel and reinforced concrete buildings. Desires position as field engineer or assistant superintendent. Available at once. B-8865.

CIVIL ENGINEER, Assoc. M. Am. Soc. C.E.; Rensselaer graduate, two years experience, design and inspection steel and concrete; seven years experience, subway construction; five and one-half years responsible charge, layout, supervision, estimates, costs, materials. C-8639.

STRUCTURAL ENGINEER, Assoc. M. Am. Soc. C.E.; age 31; married; desires responsible position. Ten years broad experience structural design on railroad viaduct and station, elevated streets, industrial buildings, bins, conveyor galleries, bridges, cement and coke oven plants, also foundations. Now employed as squad leader. C-8644.

CIVIL ENGINEER, Assoc. M. Am. Soc. C.E.; licensed professional engineer; 34; married. Ten years experience, designing of steel and reinforced concrete, construction of high-class buildings, such as tall office buildings, garages, and theatres. Desires position with leading architects, engineers, or contractors. Excellent references. Available immediately for any place in United States. C-6335.

RECENT BOOKS

New books of interest to Civil Engineers, recently donated by the publishers to the Engineering Societies Library, will be found listed here. A comprehensive statement regarding the service which the Library makes available to members is to be found on pages 77 and 78 of the Year Book for 1930. The statements made regarding the books are taken from the books themselves and this Society is not responsible for them.

L'ART DE BATIR UNE MAISON AGRÉABLE ET SAINE. By Edmond Marcotte. Paris et Liege, Librairie Polytechnique Ch. Béranger, 1930. 572 pp., cloth.

A work on the technic of building and the installation of sanitary fixtures in town and country homes in France and her colonies.

COMMERCIAL STRUCTURE OF THE PACIFIC SOUTHWEST. Published by the Government Printing Office, Washington, D.C. $1.85.

A solution to some of the California rancher's problems, and some of the effects of this solution upon nation-wide industries. Information concerning topography and climate that is important to business of every kind.

COMPARISON OF THE PHYSICAL PROPERTIES OF VARIOUS KINDS OF CAST IRON PIPE. By F. N. Menefee and A. E. White. University of Michigan. Dept. of Engineering Research Reprint series No. 6. Ann Arbor Mich., 1930. 41 pp., diagrs., tables, 9 × 6 in., paper. $.50.

Specimens of centrifugally cast, horizontally cast, and vertically cast 6-in. and 8-in. pipe were tested to determine their relative serviceability for water mains. The tests are described in detail and general conclusions are drawn.

DETAILING AND FABRICATING STRUCTURAL STEEL. By F. W. Dencer. 2nd edition. New York, McGraw-Hill Book Co., 1930. 441 pp., illus., diagrs., tables, 9 × 6 in., cloth. $5.00.

This is the most extensive work available upon structural shop practice. Engineering and shop organization, designing and specification writing, the various steps and processes of fabricating, the inspection and shipping of work are discussed in the light of practical experience. The book should be useful to all who have to do with the design and construction of steel structures. The new edition has been extensively revised and new matter has been added.

ELEMENTS OF SURVEYING. By Raymond E. Davis, Francis S. Foote, and W. H. Rayner. New York, McGraw-Hill Book Co., 1930. 581 pp., illus., diagrs., tables, 8 × 5 in., fabrikoid. $4.00.

Essentially an abridgment of *Surveying Theory and Practice*, by the same authors, and is intended as a textbook for less comprehensive courses, especially those usually given to other than civil engineering students. The aim has been to cover the fundamental principles and practices thoroughly and to teach the methods used in the more common kinds of surveys for establishing boundaries, locating railroads and highways, and topographic mapping.

ENGINEERING METALLURGY. (A Textbook for Users of Metals.) By Bradley Stoughton and Allison Butts. 2nd edition. New York, McGraw-Hill Book Co., 1930. 498 pp., illus., diagr., tables, 9 × 6 in., cloth. $4.00.

An elementary course in metallurgy, aimed at the needs of the engineer who uses metals, rather than the one who produces them. Emphasis is placed on the effects of impurities, working, heat treatment, methods of production, molecular structure, composition, etc., upon the properties of the common metals and alloys. The new edition has been revised and enlarged.

GEOMETRISCHE TRANSFORMATIONEN. By Karl Doehlemann. 2nd edition, edited by Wilhelm Olbrich. Ber. u. Lpz., Walter de Gruyter & Co., 1930. 254 pp., 10 × 6 in., paper. 13.-r.m.

Aims to present an introduction to the entire field of geometric transformations within a single volume, and in not too abstract a manner. The uses of the subject in dealing with problems of physics, machine design, and building are pointed out.

HYDRAULICS FOR ENGINEERS AND ENGINEERING STUDENTS. By Frederick Charles Lea. 5th edition. New York, Longmans, Green & Co., 1930. 775 pp., illus., diagrs., tables, 9 × 6 in., fabrikoid. $7.50.

The new edition of this well known textbook apparently has been entirely reset, and in the process the accumulated appendixes have been incorporated in the text. A considerable amount of material upon recent researches and developments and a chapter on dynamic similarity have been added. The book offers a clear, practical exposition of the fundamentals of hydraulics, with illustrations of their applications to water wheels, pumps, and hydraulic machines, and to the measurement of the flow of water.

NON-INTERPOLATING LOGARITHMS, COLOGARITHMS, AND ANTILOGARITHMS. By Frederick W. Johnson. San Francisco, The Simplified Series Publishing Co., 1930.

As stated in the preface, "Its purpose is to furnish a set of tables of logarithms, cologarithms, and antilogarithms that will, for ordinary calculations, entirely obviate the necessity for interpolation or the use of tables of proportional parts."

OLD WINDMILLS OF ENGLAND. By R. Thurston Hopkins. New York, William Farquhar Payson, 1930. 245 pp., illus., 10 × 7 in., cloth. $6.00.

Mr. Hopkins' interesting book tells of his visits to existing windmills in England, especially those in Kent and Sussex, and also contains information upon some old watermills. He has brought together much curious and interesting information upon a dying art and has increased the value of the book by a large number of good photographs.

STANDARDS AND SPECIFICATIONS FOR NON-METALLIC MINERALS AND THEIR PRODUCTS. By U. S. Bureau of Standards. (Miscellaneous publication No. 110.) U.S. Government Printing Office, 1930. 680 pp., illus., diagrs., 11 × 8 in., cloth. $2.75.

A very useful collection of the standards and specifications that have been formulated by national societies, trade associations, and other organizations of authority. The present volume deals with coal, petroleum, asphalt, and mineral wax and their products; stone, sand, and cementitious materials; glass and its products; clay and its products; abrasives, asbestos, and chalk; mica; precious stones and imitations; sulfur, magnesia, salt, and graphite.

STEAMING UP (The Autobiography of Samuel M. Vauclain, Written in Collaboration with Earl Chapin May). New York, Brewer & Warren, 1930. 298 pp., illus., ports., 9 × 6 in., cloth. $5.00.

A lively, readable book, in which the President of the Baldwin Locomotive Works reviews his active life, so intimately connected with American railroading for half a century.

VECTORIAL MECHANICS. By Louis Brand. New York, John Wiley & Sons, 1930. 544 pp., 9 × 6 in., cloth. $5.00.

An introductory textbook for students of engineering and physics. Statics, kinematics, and dynamics are discussed successively, with greater fullness than necessary for the usual college course, with the object of making the book useful also as a reference book. A simple, direct exposition that meets reasonable standards of rigor has been sought.

VERWERTUNG MAGNETISCHER MESSUNGEN ZUR MUTUNG FÜR GEOLOGEN UND BERGINGENIEURE. By Alfred Nippoldt. Berlin, Julius Springer, 1930. 74 pp., diagrs., tables, plates in pocket, 9 × 6 in., bound. 16.50 r.m.

Discusses the conclusions as to geologic structure which can be drawn from magnetic measurements on the surface. The author confines himself to the interpretation of magnetic explorations and aims to give simple directions which will meet the practical needs of mining engineers and geologists.

CURRENT PERIODICAL LITERATURE

Abstracts of Articles on Civil Engineering Subjects from Magazines in This Country and in Foreign Lands

Selected items from the current Civil Engineering Group of the Engineering Index Service, 29 West 39th Street, New York, N.Y. Every article indexed is on file in The Engineering Societies Library, one of the leading technical libraries of the world. Some 1,800 technical publications are received by the Library and are read, abstracted, and indexed by trained engineers. With the information given in the items which follow, you may obtain the article from your own files, from your local library, or direct from the publisher. Photoprints will be supplied by this Library at the cost of reproduction, 25 cents per page, or technical translations of the complete text may be obtained when necessary at cost.

CONCRETE ARCH, ARLINGTON MEMORIAL. Draw Span of Arlington Memorial Bridge, J. L. Nagle. *Military Engr.*, vol. 22, no. 126, Nov.-Dec. 1930, pp. 518–522, 3 figs. Report on design and construction of draw span having main trunnions 216 ft. center to center, live-load supports 192 ft., 2 in. center to center; draw span abutments are 184 ft. apart; deck is 90 ft. wide between balustrades; ornamental details; machinery is electrically operated by current supplied from Washington.

CONCRETE ARCH, BELGIUM. Memorial Bridge on Escaut at Eyne (Le pont commémoratif construit sur l'Escaut, a Eyne), A. Heylbroeck. *Annales des Travaux Publics de Belgique* (*Brussels*), vol. 31, no. 4, Aug. 1930, pp. 557–568, 1 fig. Design and construction of highway, concrete-arch bridge, of cellular type, 37 m. clear span, founded on bulbous concrete piles of Franki system; bridge commemorates battle of 37th Division of Ohio.

CONCRETE ARCH, CONSTRUCTION. Concrete Arch Bridge Over the Seekonk River Opened for Traffic. *Contractors and Engrs. Monthly*, vol. 21, no. 5, Nov. 1930, pp. 57–61, 9 figs. Details of design, material requirements, and construction methods for Washington Bridge between Providence and East Providence, R. I., consisting of 12-arch and 150-ft. steel double bascule lift spans; total length 2,408 ft.; width 80 ft.

DESIGN. Recent Developments in Bridge Superstructures, J. L. Harington. *Assn. Chinese and Am. Engrs.—Jl.* (*Peiping*), vol. 11, no. 10, Oct. 1930, pp. 28–42. Previously indexed from Engrs.' Soc. West. Penn.—*Proc.*, Mar. 1930.

HIGHWAY. Designing a Composite Bridge, P. L. Brockway. *Pub. Works*, vol. 61, no. 12, Dec. 1930, pp. 47–48 and 51, 6 figs. Description of bridges, built at Wichita, Kans., with estimated life of 30 years; steel beam and reinforced concrete deck supported on piles of Southern pine, with concrete or cadmium-plate hand rails.

STEEL ARCH, SYDNEY, AUSTRALIA. Erection of the Main-Span Hangars of Sydney Harbour Bridge. *Engineering* (*Lond.*), vol. 130, no. 3384, Nov. 21, 1930, p. 645, 5 figs. partly on supp. plate. There are 42 hangars in all, which vary in length from 191 ft., $10\frac{1}{2}$ in., at crown of arch, to 21 ft., $1\frac{1}{8}$ in. at first suspensed cross-girder; erection is being carried out by creeper crane carried on top chords or arch.

SUSPENSION, HUDSON RIVER. Contract HRB-10. *Port of New York Authority*, May 1930, 117 pp., 13 figs. Information for bidders' proposal, form of contract, bond, and specifications for New Jersey approach excavation and miscellaneous construction at Hudson River bridge between Fort Washington and Fort Lee; work relates to excavation and fill for New Jersey approach to Hudson River bridge; grading and paving of Hudson Terrace in vicinity of approach, and construction of piers, abutments, and retaining walls for crossing of bridge approach over Hudson Terrace.

SUSPENSION, PORTLAND, OREGON. St. John's Suspension Bridge Across Willamette River at Portland, Oregon, M. E. Reed. *West. Construction News*, vol. 5, no. 22, Nov. 25, 1930, pp. 569–572, 5 figs. Description of highway bridge which, having main span of 1,207 ft., is longest suspension bridge to be built with stranded cables in place of usual parallel wire construction; architectural treatment; details of piers; main steel towers are of tubular construction, 8 by $21\frac{1}{2}$ ft. at base, tapering to 7 ft. in either direction to height of 408 ft. above datum; cable anchorages.

BUILDINGS

APARTMENT HOUSE CONSTRUCTION. How Unusual Methods Overcame Construction Difficulties. *Am. Bldr. and Bldg. Age*, vol. 50, no. 3, Dec. 1930, pp. 66–69, 9 figs. Problem of marshy site overcome by use of mat of steel and concrete for foundations in construction of 54 Crystal Gardens apartment houses, Astoria, N.Y.

CONCRETE, DESIGN. The Aesthetic Side of Structural and Constructional Engineering, H. Robertson. *Structural Engr.* (*Lond.*), vol. 8, no. 12, Dec. 1930, pp. 410–416, 4 figs. Architect's role as artist, in relation to that of engineer, who is primarily scientist; elements of design; architectural development; recognition of structures; domestic architecture.

DESIGN. Building for Industrial Engineering Research. *Eng. News-Rec.*, vol. 105, no. 23, Dec. 4, 1930, pp. 881–884, 6 figs. Report on design and construction of U-shaped, 7-story building for engineering and research department of A. O. Smith Corp. plant, at Milwaukee, Wis.; hollow columns and girders inclose air ducts and piping; laboratory has welded steel-plate floors and mechanical ventilation; large bay windows form wall areas, with aluminum pilasters and spandrels; details of trusses for floors and craneway roof.

OFFICE, AIR CONDITIONING. Inside Air Conditions Balanced with Outdoor Temperature, W. H. Mayes. *Heat., Piping and Air Conditioning*, vol. 2, no. 12, Dec. 1930, pp. 1015–1017, 4 figs. Design and construction features of air-conditioning equipment in Norwood office building, Austin, Texas; air is recirculated; carbon dioxide compressors used; partial plan of basement; indoor temperature balanced with outdoor.

OFFICE BUILDINGS, GERMANY. Interesting Features of Salamander A.-G. Building, Berlin (Interessantes vom Bau des Hochhauses der Salamander A.-G. Berlin), A. Stawski. *Bauingenieur* (*Berlin*), vol. 11, no. 49, Dec. 5, 1930, pp. 858–860, 6 figs. Structural details of steel framing of 8-story building.

STEEL, CONSTRUCTION. Erection of a Nine-Story Steel Structure over the District Railway. *Civil Eng.* (*Lond.*), vol. 25, no. 6, Nov. 1930, pp. 299–301, 4 figs. Reconstruction of large corner building adjacent to Victoria Railway Station, London; method employed for carrying 1,500-ton steel structure over District Railway tunnel; design of rocker bearings.

CONCRETE

COLUMNS. Reinforced Concrete Design Simplified, J. R. Griffith. *Concrete*, vol. 37, no. 6, Dec. 1930, pp. 40–41. Alignment charts for spiral reinforced and A.C.I. tied columns.

DESIGN. The Principles of Reinforced Concrete, A. C. Hughes and C. S. Gray. *Surveyor* (*Lond.*), vol. 78, no. 2026, Nov. 21, 1930, pp. 515–517, 4 figs. Formulas, charts, and examples of design of rectangular beams with tension reinforcement. (To be continued.)

DAMS

BOULDER DAM PROJECT. A Complete Outline of the Boulder Canyon Project on the Colorado River, W. A. Scott. *Contractors and Engrs. Monthly*, vol. 21, no. 5, Nov. 1930, pp. 52–54 and 71, 4 figs. Outline covers location of dam site, cost and character of preliminary work required, dimensions of dam, outlets of dam, types of spillways, storage basin, rock foundation, power plant, purposes of project.

Hoover Dam, E. Mead. *Eng. Soc. Boston—Jl.*, vol. 1, no. 7, Dec. 1930, pp. 21–35, 5 figs. Concrete Dam over 700 ft. high; reservoir eight times larger than Assuan; hydro-electric machinery to develop million and quarter hp.; all-American canal to irrigate nearly one million acres, with excavation $\frac{1}{4}$ that of Panama Canal; total estimated cost of $165,000,000; such project is challenge to imagination.

CONCRETE, CONSTRUCTION. Dam on Mattawin River in Isolated Part of Quebec Built with Aid of Radio and Aeroplane. *Contract Rec.* (*Toronto*), vol. 44, no. 50, Dec. 10, 1930, pp. 1517–1523, 11 figs. Dam location, 80 mi. from railway, entailed use of radio broadcasting and receiving outfits and aerial service; dam, 90 ft. high and 2,400 ft. long at crest, required 52,000 cu. yd. of concrete and 187,000 cu. yd. of earth fill.

Distribution Reservoir Design, C. A. Smith. *West. City*, vol. 6, no. 12, Dec. 1930, pp. 19–25, 6 figs. Preliminary surveys and investigations; excavation and embankment slopes; selection of embankment materials; protection of outlet pipes; embankment construction; reservoir lining; reinforcement; expansion joints; waterproofing; underdrains; storm drainage and overflow provisions; costs. Paper read before Am. Water Works Assn.

Dropping a Dam Into Place. *Assn. Chinese and Am. Engrs.—Jl.* (*Peiping*), vol. 11, No. 10, Oct. 1930, pp. 43–44. Previously indexed from Pub. Works, Oct. 1930.

EARTHQUAKE EFFECT. Must Seismic Stresses Be Considered in the Design of Dams (Si devono considerate sollecitazioni sismiche nelle dighie), C. Guidi. *Ingegnere* (*Milan*), vol. 4, no. 6, June 1930, pp. 375–376; see also brief translated abstract in *Eng. News-Rec.*, vol. 105, no. 24, Dec. 11, 1930, p. 931. Earthquake stresses on reservoir dams, with special reference to studies for new Pasadena dam in San Gabriel Canyon, California; author proposes that for dam construction in earthquake zones, vertical loads be augmented by 50 per cent and horizontal load be assumed at one-eighth of weight of structure.

EARTH, CONSTRUCTION. Earth Dam with Corewall to Impound 4 Billion Gallons, T. H. Wittkorn. *Contractors and Engrs. Monthly*, vol. 21, no. 5, Nov. 1930, pp. 68–71, 7 figs. Construction methods used on 2,000-ft. dam on Crum Creek, Delaware Co., Pa., which will raise stream 70 ft. and inundate 400 acres.

EARTH-FILL, WANAQUE, N.J. The Wanaque Water-Works Project, A. H. Pratt. *New England Water Works Assn.—Jl.*, vol. 44, no. 3, Sept. 1930, pp. 387–450, 29 figs. Report on development of project for water supply of North Metropolitan District of New Jersey, which involved construction of earth-fill concrete-core dam, 103 ft. high, with cut-off trench, 100 ft. maximum depth, also several smaller dams and aqueduct 20 mi. long, consisting mainly of 74-in. twin-steel pipe line; cost will approximate $27,000,000; relocation of highways and railroad; operation of Wanaque Reservoir.

EARTH, MATERIALS. Materials in Existing Earth Dams, E. W. Lane. *Eng. News-Rec.*, vol. 105, no. 25, Dec. 18, 1930, pp. 961–965, 3 figs. Research Engineer of U.S. Bureau of Reclamation presents mechanical analysis of materials of rolled-fill dams; borrow pit materials of hydraulic-fill dams; hydraulic-fill dams; hydraulic core material.

HYDRAULIC-FILL, COBBLE MOUNTAIN. Tunnel Blasting at Cobble Mountain, H. H. Hatch. *Eng. Soc. Boston—Jl.*, vol. 1, no. 6, Nov. 1930, pp. 7–17, 8 figs.; see also *Explosives Engr.*, vol. 8, no. 5, May 1930, pp. 169–172, 8 figs. Report on construction of highest hydraulic-fill dam in world; maximum height over 255 ft. from bottom of cut-off wall trench; massive bodies of rock at each toe, giving stability; how tunnels were driven and loaded; description of tunnel shooting.

HYDRAULIC-FILL, CORES. Hydraulic-Fill Core Control, C. E. Waddell. *Eng. News-Rec.*, vol. 105, no. 25, Dec. 18, 1930, pp. 958–961, 7 figs. Method of core testing first used by writer on Bee Tree Dam, of Asheville water supply, which is earth and rock-fill dam 177 ft. high, built by

semi-hydraulic-fill process; equipment for core sampling; collecting samples; laboratory analysis; deflocculating; microscopic test; drying and screening; recording of results.

OVERFLOW. Research on Overflow Dams (Recherches sur les barrages déversoirs), L. Escande. *Bul. Technique de la Suisse Romande (Lausanne)*, vol. 56, nos. 17, 18, and 19, Aug. 23, 1930, pp. 207–210, Sept. 6, pp. 217–220, and Sept. 20, pp. 232–234, 7 figs. Report on experimental studies made at Electrotechnical Institute of Toulouse to investigate laws of hydraulic similitude and their application to models of two projected overflow dams; analysis of flow over crest of Pinet Dam; distribution of velocities and of pressures upon surface of dam and within its mass. (To be continued.)

RESERVOIRS, STORAGE. Harnessing the Upper Hudson. *Oil-Power*, vol. 5, no. 10, Nov. 1930, pp. 149–154, 6 figs. Completion of new Sacandaga reservoir, largest man-made reservoir in New York State, at Conklingville, N.Y., is another constructive step in plan for regulating flow of Hudson, as well as for producing hydro-electric power; design and construction features.

WEIRS, DISCHARGE. Energy Losses Over Long Crested Weirs, J. D. H. Bedford and A. M. R. Montagu. *Punjab Eng. Congress—Proc. (Lahore)*, vol. 18, 1930, pp. 183–191 and (discussion) 192a-192k, 1 fig., 4 plates. Experimental and theoretical study of wier formulas leading to conclusion that, instead of using variable wier coefficient, it might be preferable to gage discharge on basis of loss of head between gage site and downstream edge of wier crest.

FLOOD CONTROL

MISSISSIPPI RIVER. The Defense Against Old Man River, R. K. Tomlin. *Construction Methods*, vol. 12, no. 12, Dec. 1930, pp. 50–53, 14 figs. Features of improved tower excavator and clamshell dredge; new machine is equipped with structural-steel mast 120 ft. high, guyed by wire rope cables to rear and sides of frame, and reinforced by pair of inclined stiff legs which serve also as a frame for erection of mast; independently operated head and tail towers supporting 1$^3/_8$-in. cable track of at least 650-ft. span; 10-yd. bucket is hauled in by 1$^3/_8$-in. drag cable, with provision for $_5/_8$-in. backhaul cable. (Concluded.)

STREAM EROSION. Erosion Problems on Dredged Channels as Related to Bank Protection, C. H. Young and R. Harbaugh. *Iowa Eng. Soc.—Proc.*, vol. 5, no. 4, Oct. 1930, pp. 61–66. Erosion problems encountered in projects, which extend along Mississippi River from northern limits to southern limits of state; these projects are centered around tributary streams which drain into Mississippi River both in Iowa and in Illinois.

FLOW OF FLUIDS

FLOW OF WATER, UNDERGROUND. Hydraulic Gradients in Subsoil Water Flow in Relation to Stability of Structures Resting on Saturated Soils, A. N. Khosla. *Punjab Eng. Progress—Proc. (Lahore)*, vol. 18, 1930, pp. 137–151 and (discussion) 152a-152r, 9 figs., 18 supp. plates. Report on experimental work for remedying trouble in upstream and downstream floors of drainage siphons on Upper Chenab Canal; pressures under floor under varying conditions of canal supply and spring level; location of relief strainers; true free water level vs. apparent free water level; loss of head curve; velocity of subsoil water flow; undermining of foundations; wells versus sheet piles; piling up of water pressure against steel piles; critical head.

WATER, BENDS. Some Aspects of Flow Around Bends, Bridge Piers, and Over Highway and Railway Embankments, D. L. Yarnell. *Iowa Eng. Soc.—Proc.*, vol. 5, no. 4, Oct. 1930, pp. 31–44, 18 figs. Researches on bends undertaken for purpose of determining laws governing changes in pressure and velocity in different parts of flowing stream, as moving water undergoes transition from motion along straight line to motion around bend, and again as it undergoes opposite transition back to final straight-line motion.

HYDRO-ELECTRIC POWER PLANTS

CANADA. Beauharnois Power Plan on St. Lawrence River Designed for Full Flow of the Stream. *Eng. News-Rec.*, vol. 105, no. 24, Dec. 11, 1930, pp. 916–922, 9 figs. Construction of power canal, 15$^1/_2$ mi. long, 600-ft. bottom width, to connect Lake St. Francis and Lake St. Louis sections of St. Lawrence River designed for ultimate enlargement to take flow of 53,000 sec-ft.; hydraulic dredge making cut for power canal; tower excavators of 10-cu. yd. capacity and maximum span of 900 ft. used; details of river control works; dragline excavator working in boulder clay has bucket capacity of 4 cu. yd.; cars are standard-gage air dumps of 20-cu. yd. capacity.

FLUMES, CONCRETE. Power-Driven Equipment Brings Speed and Economy to Large Concrete Flume Job. *Construction Methods*, vol. 12, no. 12, Dec. 1930, pp. 32–35, 9 figs. Report on high-speed construction of reinforced-concrete flume, 18$^3/_4$ mi. long, 14 ft. wide, and 7 ft. deep, being built by Pacific Gas & Electric Co. as part of Mokelumne River development program; use of seven-trailers-and-tractor train which can travel at about 10 miles per hour; four portable mixing plants are used; features of self-propelled tractor hoisting and form-setting jumbos.

TIGER CREEK CONDUIT. *West. Construction News*, vol. 5, no. 23, Dec. 10, 1930, pp. 592–596, 6 figs. Construction of conduit, 21$^1/_2$ mi. long, consisting of concrete flume 14 ft. wide and 7 ft. deep, of 550 cu. ft. per sec. capacity, 18$^3/_4$ mi. long, interspersed with 7 tunnels, for Mokelumne River hydro-electric project, California; quarries and concrete aggregates; distributing aggregates; tractor hoisting; form setting; form stripping, and concreting jumbos; concrete mix and control; trestles, bridges, and siphons; intercepting local run-off; Tiger Creek regulating reservoir.

INLAND WATERWAYS

CANALS, CALIFORNIA. Stockton Deep-Water Ship Channel. *West. Construction News*, vol. 5 no. 22, Nov. 25, 1930, pp. 573–575, 7 figs. Progress reports on excavation and levee-construction contracts on canal described in article previously indexed from issue of June 10, 1930.

WELLAND SHIP CANAL. The Construction of the Steel Lock Gates of the Welland Ship Canal, E. S. Mattice. *Eng. Jl. (Montreal)*, vol. 13, no. 12, Dec. 1930, pp. 671–677, 10 figs. Some shop and field problems; precautions taken to insure accuracy and water-tightness in design; refinements which might have been made to reduce cost of work.

IRRIGATION

NEW MEXICO. Middle Rio Grande Conservancy District, New Mexico, J. D. Holmes. *West. Construction News*, vol. 5, no. 22, Nov. 25, 1930, pp. 566–568, 3 figs. Works and activities of Conservancy District, consisting of flood control, drainage, and irrigation over area 150 mi. long and 1 to 5 mi. wide, in counties of Sandoval, Bernalillo, Valencia, and Socorro, 50 mi. north to 100 mi. south of Albuquerque; four diversion dams will be built across river at about equal intervals.

MATERIALS TESTING

BITUMINOUS MATERIALS. Ductility of Bituminous Materials. *Am. Soc. Testing Matls.—Tentative Standards*, 1930, pp. 448–450, 1 fig. Ductility of asphalt cement or semi-solid bitumen is measured by distance to which it will elongate before breaking when two ends of briquet of material are pulled apart at specified rate of speed and at specified temperature, which for normal test shall by 5 cm. per min. at 25 deg. cent.

BUILDING STONE. Tentative Method of Compression Testing of Natural Building Stone. *Am. Soc. Testing Matls.—Tentative Standards*, 1930, pp. 510–512, 1 fig. Method of test is intended for determination of compressive strength of natural building stones used for exterior or interior construction or decorative purposes.

CONCRETE. Compressive Strength of Concrete in Flexure—As Determined from Tests of Reinforced Beams, W. A. Slater and I. Lyse. *Am. Concrete Inst.—Jl.*, vol. 2, no. 4, Dec. 1930, pp. 377–383. Discussion by F. Emperger of paper indexed from issue of June 1930; also author's closure.

Consistency of Portland-Cement Concrete. *Am. Soc. Testing Matls.—Tentative Standards*, 1930, pp. 446–447, 1 fig. Test covers method to be used in laboratory and in field for determining consistency of concrete.

METALS. Tentative Methods of Compression Testing of Metallic Materials. *Am. Soc. Testing Matls.—Tentative Standards*, 1930, pp. 765–769, 3 figs. Methods deal with form and dimensions, machining, and testing of compression test specimens of metallic materials.

REFRACTORY MATERIALS. Testing Equipment for Refractory Materials, L. Litinsky. *Ceramic Age*, vol. 16, no. 6, Dec. 1930, pp. 332–335, 15 figs. Such accessory equipment as saws, boring machines, equipment for grinding thin sections, and pyrometers is discussed.

STEEL. Acceptance Tests of Gear Steel. *Metal Progress*, vol. 18, no. 6, Dec. 1930, pp. 91–94, 4 figs. System of steel inspection of Brown-Lipe-Chapin, with particular reference to cleanliness, normality, grain size, and hardenability; data on compensation and deep etch test.

WELDS. The Strength of Electric Arc Welds in Structural Mild Steel, R. R. Blackwood. *Commonwealth Engr. (Melbourne)*, vol. 18, no. 3, Oct. 1930, pp. 89–97, 7 figs. Results of tests on side-welded specimens designed to show variation in strength of fillet with both length and size of fillet tested; results indicate that there is no reduction of strength with increased length of fillet, and that relation between strength and size of fillet is not linear, smaller welds being relatively stronger. (Continuation of serial.)

PUBLIC WORKS ENGINEERING

NEW ZEALAND. Public Works in New Zealand, H. E. Babbitt. *Eng. News-Rec.*, vol. 105, no. 25, Dec. 18, 1930, pp. 966–968, 4 figs. Travel notes on railroad and bridge construction; railroad tunnels; expenditures by Public Works Department of New Zealand for year ended March 31, 1929; hydro-electric development.

RAILROADS, STATIONS, AND TERMINALS

DESIGN. Modern Railway Passenger Terminals, A. Fellheimer. *Arch. Forum*, vol. 53, no. 6, Dec. 1930, pt. 1, pp. 655–694, 55 figs. Problems to consider in creation of basic scheme; general and specific requirements; elaboration of design; illustrations of stations in Buffalo, Philadelphia, Cleveland, Helsingfors, Konigsberg, Stuttgart, Viborg, Omaha, South Bend, Erie, Atlanta, Topeka, Madison, N.J., East Los Angeles.

ROADS AND STREETS

CONCRETE. Lean Harsh Concrete, R. V. F. Eldridge. *Commonwealth Engr. (Melbourne)*, vol. 18, no. 3, Oct. 1930, pp. 98–101, 5 figs. Author states that successful mixes have been used in road construction with very small proportion of 1 part of cement to 12 or 14 of sand and stone; some samples of this concrete have been tested and have shown compressive strengths above 4,000 lb. per sq. in. and figures for modulus of rupture as high as 660 lb. per sq. in.; he states that it is quality of cement water paste that determines strength and quality of concrete mixture.

Results Obtained by the Use of Cement, F. T. Sheets, R. W. Crum, A. N. Johnson, E. M. Fleming, C. Older, and R. E. Toms. *Pub. Roads*, vol. 11, no. 9, Nov. 1930, pp. 184–188. Structural design of concrete pavements; materials; design of concrete mixtures and methods of proportioning; construction of concrete pavements; maintenance of concrete pavements. Report of American engineers to Sixth International Road Congress. Bibliography.

CONCRETE, CONSTRUCTION. Building a By-Pass Highway in a Rocky Section of Pennsylvania, R. G. Skerrett. *Compressed Air Mag.*, vol. 35, no. 11, Nov. 1930, pp. 3298–3301, 14 figs. Seven-mile concrete road between Wilkes-Barre and Pittston, Pa., with paved surface 20 ft. wide and 10-ft. shoulder on either side, is marked by several deep cuts mainly through rock.

CONCRETE, ILLINOIS. Three Illinois Counties Ride on One-Lane Concrete Roads. *Roads and Streets*, vol. 70, no. 12, Dec. 1930, pp. 443–445, 6 figs. Champaign, Iroquois, and Vermilion counties have decided in favor of having more miles of one-lane paved surfaces; farm-to-market roads available 365 days in year; widening can be accomplished efficiently when needed; three counties have 420 mi. of one-lane roads.

CONSTRUCTION. Present Trends in City Paving, J. S. Burch, Jr. *Pub. Works*, vol. 61, no. 12, Dec. 1930, pp. 21–22, 72 and 74, 6 figs. Notable advance in quality of design and care in construction; increased width; speed of construction; improvements in concrete, brick, asphalt, and low-cost types.

CONSTRUCTION, CHINA. China's Awakened Interest in Highway Building, S. A. Zweibel. *Far East. Rev. (Shanghai)*, vol. 26, no. 10, Oct. 1930, pp. 560–566, 26 figs. Organization and work of National Good Roads Assn. of China; benefits derived from good roads; construction methods used.

CRUSHED STONE. Tentative Specifications for Broken Stone for Bituminous Concrete Base. *Am. Soc. Testing Matls.—Tentative Standards*, 1930, pp. 412–413. Specifications cover quality and grading of broken stone to be used in construction of closed-mix and open-mix bituminous concrete base.

DESIGN. Reducing Rural Highway Congestion and Accidents by Proper Design, M. Halsey. *Am. City*, vol. 43, no. 6, Dec. 1930, pp. 117–119, 6 figs. How traffic control can be built into highway; use of medial strips on parkways; improved shoulders for parking; clearance from guard-rail; dual type highways; attracting traffic to outer lanes; channelizing islands; grade separation. Paper read before Nat. Safety Congress.

HIGHWAY ENGINEERING, UNITED STATES. The Highways of the U.S.A., T. W. Allen. *Roads and Road Construction (Lond.)*, vol. 8, no. 95, Nov. 1, 1930, pp. 394–396, 9 figs. Work of U.S. Bureau of Public Roads in rural highway improvement; sources of income from states,

counties, and townships; current construction methods, types of roads, and costs. (To be continued.)

MOUNTAIN, CONSTRUCTION. Grading with 7-yd. Scrapers. *Eng. and Contracting*, vol. 69, no. 12, Dec. 1930, pp. 431–432, 3 figs. Scraper-grading and use of bulldozers and rooters prove economical on two mountain-road jobs in California.

NEW YORK. Reconstructing an Important New York Thoroughfare, C. M. Pinckney. *Roads and Streets*, vol. 70, no. 12, Dec. 1930, pp. 421–425, 14 figs. Widening of Church Street and merging into Sixth Avenue extension, New York, made possible by construction of Eighth Avenue subway; repavement with concrete base, and granite block with bituminous filler.

PAVEMENTS, ASPHALT. Asphalt Paving Plant Operations, J. W. Davitt. *Can. Engr.* (*Toronto*), vol. 59, no. 22, Nov. 25, 1930, p. 658. Paper presented before Engrs' Club, previously indexed from Engrs. and Eng., June 1930.

PAVEMENTS, CONCRETE. Efficient Operation of Concrete Paving in Pennsylvania, P. M. Tebbs. *Pub. Works*, vol. 61, no. 9, Sept. 1930, pp. 23–25, 10 figs. Chart showing location on job of each man and piece of equipment; analysis of lost time.

Seattle's Concrete Pavements Cured with Continuous Sprinkler, H. F. Faulkner. *Concrete*, vol. 37, no. 6, Dec. 1930, pp. 1920, 4 figs. City specifications require continuous curing for 10 days; either sprinkling or ponding permitted, but former is more economical; sprinkler head designed especially for paving work; cost data.

WIDENING. Fill—Now You Have It and Now You Don't. *Contractors and Engrs. Monthly*, vol. 21, no. 5, Nov. 1930, pp. 49–51, 6 figs. Work of widening 16-ft. brick highway in West Virginia to 20-ft. road with 10-ft. shoulder on either side, requiring 205,000 cu. yd. of excavation and 2,205,000 station yards overhaul.

SEWERAGE AND SEWAGE DISPOSAL

ACTIVATED SLUDGE. Small Activated Sludge Installations, F. M. Veatch. *Can. Engr.* (*Toronto*), vol. 59, no. 24, Dec. 9, 1930, pp. 703–704. Principal features of process and comparison with other methods of sewage disposal; power consumption for process; effect of industrial wastes. Paper presented at Missouri Water and Sewerage Conference.

Using the Abridged Activated Sludge Process for Relieving Load of Existing Sewage Disposal Plants (Ueber die Anwendbarkeit des abgekuerzten Belebtschlammverfahrens zur Entlastung bestehender Klaeranlagen), O. Kammann and O. Herb. *Technisches Gemeindeblatt* (*Berlin*), vol. 33, no. 12, June 20, 1930, pp. 147–149. Report from State Institute of Hygiene, Hamburg, reviewing American and British practice and summarizing results of experiments made in Hamburg.

GAS RECOVERY. The Sewage Disposal Plant of Iserlohn, Westphalia, the First Activated Sludge Plant Operated with Sludge Gas (Die Klaeranlage Iserlohn i.W., die erste Schlammbelebungsanlage mit Schlammgasantrieb), W. Schmidt. *Technisches Gemeindeblatt* (*Berlin*), vol. 33, no. 11, June 5, 1930, pp. 133–138, 10 figs. Description of plant, serving population of 19,000, combining activated sludge process with gas recovery from sludge; gas motors using recovered gas supply practically all of power necessary to plant, which amounts to about 20 hp.

MODERN METHODS. Modern Treatment and Disposal of Sewage, Especially as Affecting Trade Wastes, T. P. Francis. *Surveyor* (*Lond.*), vol. 78, no. 2026, Nov. 21, 1930, pp. 521–522, and (discussion) 522–523. Domestic sewage treatment; sludge treatment; trade waste treatment; trend of developments in technic. Paper presented at meeting of Instn. Mun. and County Engrs.

SAN ANTONIO, TEX. Large Activated-Sludge Plant for San Antonio, Tex., H. R. F. Helland. *Eng. News-Rec.*, vol. 105, no. 23, Dec. 4, 1930, pp. 886–887, 3 figs. Features of sewage disposal plant which will have capacity of 30 m.g.d.; effluent may be used for irrigation; sewage is metered, screened, cleared of grit, and pre-settled before being subjected to activation by spiral air flow and to final settlement; sludge is digested in covered tanks and sent to large lagoons; gas from digestion tanks burns screenings and heats water to provide optimum temperature in digestion tanks.

SEWAGE TREATMENT. Improved Methods of Treating Sewage, W. A. Hardenbergh. *Domestic Eng.* (*Chicago*), vol. 133, no. 6, Dec. 13, 1930, pp. 50–52, 84 and 87, 6 figs. Brief discussion of different methods of disposal.

SEWERS, CONCRETE. Concrete Sewer Design Adopted as Standard After Severe Test. *Eng. News-Rec.*, vol. 105, no. 24, Dec. 11, 1930, pp. 937–938, 2 figs. Structural details of standard horseshoe-type reinforced-concrete sewer section equivalent in capacity to circular pipe with diameters from 60 to 144 in.; as final check test was conducted upon 8-ft. section equivalent in size to 84-in. circle; reinforcement data.

SLUDGE AERATION. Sludge-Aeration Experiments, E. J. Theriault and P. D. McNamee. *Ind. and Eng. Chem.*, vol. 22, no. 12, Dec. 1930, pp. 1330–1336, 10 figs. Improved apparatus of simple construction is described for continuous aeration of liquid in closed system; employing this device, oxygenation of sewage sludge is shown to conform very closely to equations of unimolecular type; velocity constants are deduced for respective rates of satisfaction of immediate and of first-stage oxygen demand of sludge.

WINONA LAKE, IND. Sewage Disposal Planned at Winona Lake, Ind., C. Brossman. *Am. City*, vol. 43, no. 6, Dec. 1930, pp. 97–100, 8 figs. Description of sewer system and sewage disposal plant costing $101,881.70; operation costs; type of buildings; ventilation problems; pumping equipment; laying of sewers.

STRUCTURAL ENGINEERING

VIADUCTS, SEATTLE, WASH. Working Stress of 1,200 lb. Used for 39-ft. Concrete Slab, C. H. Eldridge. *Eng. News-Rec.*, vol. 105, no. 25, Dec. 18, 1930, pp. 981–982, 6 figs. Limited clearance necessitates shallow floor system; Second Avenue extension viaduct in Seattle; unusual details, including unsupported expansion joint through 15-in. slab, using steel dowels, and novel method of supporting slab on lower flange of plate girder; detail of slab connection to girder.

TUNNELS

RAILROAD, GREAT BRITAIN. The Opening Out of Cofton Tunnel, London, Midland, and Scottish Railway, R. T. McCallum. *Engineer* (*Lond.*), vol. 150, no. 3906, Nov. 21, 1930, p. 565. Objects of works described were removal of old and small double main-line tunnel, 440 yd. long, and making open cutting so formed wide enough to take two additional lines on its eastern side; method for felling tunnel was to construct temporary diversion for main line on eastern side of cutting about 3 ft. above springing level of arch; slips are classified into three distinct types. Abstract of paper to be brought forward for discussion at Instn. Civil Engrs.

VEHICULAR, DETROIT. The Detroit-Windsor Tunnel. *Engineering* (*Lond.*), vol. 130, no. 3386, Dec. 5, 1930, pp. 702–705, 6 figs. Tunnel is noteworthy only in that its shield was 32 ft., 3 1/2 in. in diam. and 15 ft., 3 1/2 in. long, the largest ever designed and used in United States; most noteworthy feature of this part of work is use of structural-steel lining plates throughout, in place of cast iron; system of ventilation adopted is transverse method, i. e., fresh air is admitted at intervals on each side near roadway, and, rising transversely, is exhausted through openings in ceiling. (Concluded.)

WATER PIPE LINES

AQUEDUCT, COLORADO RIVER. Parker Route Costing $200,664,000 Recommended for Colorado River Aqueduct. *West. City*, vol. 6, no. 12, Dec. 1930, pp. 37–41, 1 fig. Discussion of comparative data on alternate Colorado River Aqueduct routes.

AQUEDUCT, CONCRETE. Concrete Aqueduct Irrigates Half Million Acres, G. P. French. *Concrete*, vol. 37, no. 6, Dec. 1930, p. 39, 2 figs. Structure is two miles long; main feature in Canadian Pacific Railway irrigation project; inverted siphon of concrete carries water under railway tracks.

CONSTRUCTION. American Foundation Methods (Amerikanische Gruendungsverfahren), H. Griesel. *Bauingenieur* (*Berlin*), vol. 11, no. 6, Feb. 7, 1930, pp. 91–96, 13 figs.; see also brief translated abstract in *Am. Concrete Inst.—Jl.*, vol. 2, no. 3, Nov. 1930, p. 82. Foundations with wooden, concrete, reinforced-concrete, Raymond piles, and combinations of wood and concrete piles; pile driving and necessary equipment; caissons can be placed either by excavating or by means of compressed air; foundation job during construction of Delaware bridge between Philadelphia and Camden is described with dimensions and graphs; several foundations of skyscraper buildings are illustrated.

SUBAQUEOUS. Huge Cast-Iron Pipe Line Carries Cables Under River. *Construction Methods*, vol. 12, no. 12, Dec. 1930, pp. 36–38, 11 figs. Construction of subaqueous crossing of 84-in. diam., cast-iron pipe, placed in 72-ft. sections with aid of specially designed "strongback" and powerful floating derrick, for carrying 148 duct lines of New York Telephone Co., underneath Harlem River at 129th St., New York; jacketing pipe with concrete after it is lowered to place on bed of river.

WELDING. Pipe Line Welding, R. W. Boggs. *Domestic Eng.* (*Chicago*), vol. 133, no. 6, Dec. 13, 1930, pp. 42–46, 10 figs. Development of welding method of pipe-line construction, inspection, and selection of material; design of joint; preparation for welding; final inspection and testing.

Welded Steel Water Main Constructed for San Diego. *Water Works Eng.*, vol. 88, no. 24, Nov. 19, 1930, p. 1734, 2 figs. Features of new steel pipe line from Otay Reservoir, 36 to 40 in. in diam., about 86,000 ft. long; method of electric welding.

WATER RESOURCES

SUPPLY, NEW MEXICO. Surface Water Supply of New Mexico 1928–29, H. W. Yeo. Santa Fe, New Mexico, 248 pp., tables. Reports for 80 gaging stations on streams originating in or flowing through New Mexico; 68 of stations are equipped with automatic, water-level recorders.

WATER TREATMENT

CHLORINATION. Recent Developments in Chlorination, F. D. West. *Pub. Works*, vol. 61, no. 12, Dec. 1930, pp. 23, 76, and 78. Latest theories as to action of chlorine on bacteria; importance of thorough distribution; deferring action by formation of chloramines; alkalinity desirable. Presented before New Eng. Water Works Assn.

DRINKING WATER SYSTEMS. Preparing Drinking Water, L. M. Jordan. *Ice and Cold Storage* (*Lond.*), vol. 33, no. 393, Dec. 1930, pp. 317–318, 2 figs. Two methods usually employed when installing cooled drinking-water system are given, together with some details of necessary equipment; operation and equipment; diagrammatic representation of open and closed systems; size and capacity of plant.

FILTRATION PLANTS, CHICAGO. Filtration of Chicago Water Supply, L. D. Gayton. *West. Soc. Engrs.—Jl.*, vol. 35, no. 5, Oct. 1930, pp. 343–362, 5 figs. Results of two years' operation of experimental filtration plant built by city to find out whether its public water supply can be made palatable; results show that it can be done with increase of two cents per thousand gallons over present rate which is now lowest of any large city; without filtration, dosage of chlorine must be increased and will ultimately become unsafe.

FILTRATION PLANTS, OPERATION. Control of Filter Plant Operation, G. F. Gilkinson. *Can. Engr.* (*Toronto*), vol. 59, no. 24, Dec. 1930, p. 694. Laboratory tests at water purification plants and advantages of control; pre-sedimentation tests; hydrogen-ion concentration; residual chlorine tests.

NEW YORK CITY. Control of Microscopic Organisms in Public Water Supplies, with Particular Reference to New York City, F. E. Hale. *New England Water Works Assn.—Jl.*, vol. 44, no. 3, Sept. 1930, pp. 361–379 and (discussion) 379–385, 8 figs. Use of copper sulfate; methods of dosing reservoirs with copper sulfate from rowboat or launch; treatment of large reservoirs with copper sulfate, New York City; solution-feed devices; points of draft aeration; use of chlorine; chemicals required for treatment of different genera.

WATER WORKS ENGINEERING

AUSTRALIA. Canberra, Australia's New Capital. *Eng. News-Rec.*, vol. 105, no. 23, Dec. 4, 1930, pp. 876–879, 9 figs. Federal capital, begun in open country in 1921, now has 6,000 population; city plan adopted before war; modest federal buildings put up instead of monumental ones then proposed; water supply and sewage disposal; garbage service; electricity and gas supply; construction materials; local government.

IMPROVEMENT IN METHODS. Opportunities for Improving Water-Works Economy. *Am. City*, vol. 43, no. 6, Dec. 1930, pp. 103–105, 3 figs. Factors governing choice of system of water supply; prime movers for pumps; electric power; use of Diesel motors; examples of Diesel installations; combined water, light, and power plants; Diesel-driven centrifugal installation.

KOBE, JAPAN. Kobe Municipal Water Works Extension Program, E. Kusano. *Far East. Rev.* (*Shanghai*), vol. 26, no. 10, Oct. 1930, pp. 541–545, 16 figs. partly on supp. plate. Development of Kobe municipal water works project consisting of heightening of Senkari reservoir dam by 20 ft. to 140 ft., thereby increasing raw water holding-capacity from 213,000,000 cu. ft. to 417,000,000 cu. ft., of building new water way including tunnels and box culverts, of constructing new clean water reservoirs here and there, of extending existing waterworks, of establishing new rapid filter system, and of extending distribution mains.